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AGRICULTURAL RESEARCH ADMINISTRATION

A REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1943

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MEETING WARTIME PROBLEMS THROUGH STATION RESEARCH

Station research aids food production.—Without reservation, the resources of the State agricultural experiment stations have been dedicated to the job of supplying the facts needed to solve the many problems involved in the record demands for food occasioned by the war. Although faced with difficulties in retaining adequate staffs of trained research workers and in maintaining essential facilities, the experiment stations in 1943 progressively increased the volume of their services and further intensified their investigations of urgent emergency problems, with the goal of maximum food production having first priority.

The production of maximum quantities of specified foods, oils, and fibers must be based on maximum use of technical information.

[1] Submitted in accordance with the requirement that the Secretary of Agriculture shall report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation.

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It calls for concentrated research by the stations and the Department on problems involved in the farmers' attempts to expand the production of familiar products and grow new crops of strategic value. But for the large accumulation of data from past research and the all-out application of research agencies to the job of interpreting and applying accumulated facts and acquiring new facts as needed, farmers would be confronted with an almost impossible task.

In attempting to meet the record demands for information that have accompanied the record demands for agricultural products, the stations have concentrated their attack on major problems involved in the effort to increase the production of specific foods for human consumption and to replace essential agricultural products formerly imported. Increasing the volume of plant products calls for greater efficiency in using soil resources, superior seed stocks of improved crop varieties, improved growing and harvesting practices, and reduction of losses from insect pests, diseases, and weeds. Meeting increased demands for animal products involves, among other problems, that of producing more feed for livestock and especially maximum use of pasture and roughages, and means of providing substitutes for feedstuffs in limited supply.

Problems of food utilization include processing to reduce bulk and facilitate transportation, finding methods for conserving nutritive values of foods, and the discovery of more facts concerning the nutrients in specific foods. The human and physical adjustments involved in demands for increased production on the one hand and restriction of production facilities on the other, and in changing market and transportation situations, present a group of variable and complex problems for research attack.

How the stations met and helped to solve problems such as these is told through a number of specific examples later in this report.

Adjusting station research for maximum service.—Steps taken by the stations to solve emergency problems have included restudy of existing data, the shifting of emphasis and speed-up of research under way, and the undertaking of many new research projects. The ever-expanding demand for farm products has been met by the continuous adjustment of station research programs through joint participation by the stations and the Office of Experiment Stations in the planning of projects and procedures to render the most effective services and to furnish the needed facts as promptly as possible.

The adjustment of station research programs, fully attuned to the war effort in 1942, was continued at a high level in 1943 in line with changing requirements. New research projects were undertaken and current work was redirected where needed to meet the most urgent demands of the food situation. Adjustments made in 1942 involved the undertaking of 821 new and revised projects under Federal-grant funds in a program that covered a total of 3,472 projects. Compared with the 5 preceding years, this represented an increase in adjustment of work of 55 percent and an increase in volume of 16 percent. Continuing adjustments in 1943 resulted in the undertaking of 724 new and revised projects in a program that covered a total of 3,419 projects.

Station-Department cooperation.—A considerable part of the research work of the stations is carried on in cooperation with bureaus of the Agricultural Research Administration and other agencies of the

United States Department of Agriculture, some through formal memoranda of understanding and some by informal exchange of information and results. In much of this work the physical plant facilities of the stations, including land, housing, animals, equipment, and supplies, are utilized, as well as personnel assigned to specific studies under cooperative memoranda. Likewise, personnel, equipment, and supplies of the Department are utilized at the stations and elsewhere in furthering such cooperative research.

A number of the examples of station contributions in 1943 cited later in this report are based on cooperation with the Department and are acknowledged as such. A general acknowledgment of close teamwork between the stations and the Department in many important lines of inquiry will perhaps suffice for instances where no specific mention of cooperation is made.

The exigency of wartime has accelerated cooperation in research among the stations and between the stations and the Department, the trend being toward more specific alignments rather than more cases involving formal understandings. In 1943, adjustments of work under formal agreements to wartime needs involved clearance and approval by the Office of Experiment Stations of more than 1,200 renewals and new and revised memoranda of understanding covering about 1,050 major research undertakings by the stations in cooperation with bureaus of the Agricultural Research Administration and agencies of the War Food Administration.

Teamwork on regional and national lines.—Added impetus to the pooling of station research efforts and results has come through the constantly growing demand upon the United States for food. Before the war the station directors had organized by regional groups to facilitate cooperation on problems of mutual concern, including cooperation with regional laboratories of the Department. The experiment station subsection of the Association of Land-Grant Colleges and Universities, and especially the Committee on Experiment Station Organization and Policy, have been major factors in facilitating teamwork along national lines. As a part of its function of administering the Federal-grant funds for experiment station research, including assistance in the coordination of research among the stations and between the stations and the Department, the Office of Experiment Stations has worked with these regional and national groups of directors in a number of important matters.

The Nation-wide cooperative study of the Conservation of Nutritive Value of Foods, organized through regional and national conferences of directors and station workers and members of the staff of the Office of Experiment Stations in 1942 at the suggestion of the National Research Council, became an active reality in 1943. More than 60 different foods were under investigation by 44 participating stations and noteworthy progress was made, as will be noted under some examples of results cited later in this report. The Chief of the Office serves as the national coordinator of this study with a station director serving as the coordinator for each of the 4 regions.

A national study involving 27 stations and the Department is designed to determine to what extent butter in the usual trade channels can be depended on to provide a uniform supply of vitamin A. Butter samples obtained in various areas in different seasons are analyzed as

to vitamin A content under standard procedures developed by a committee of the cooperating agencies. Some of the stations had completed a year's study at the close of 1943 and a preliminary report was contemplated.

A regional study undertaken simultaneously by 14 stations in Corn Belt States and the Bureau of Agricultural Economics on the marketing of livestock and livestock products resulted during the year in a published report for the region as a whole on one phase of the study. This is to be followed by reports on localized aspects to provide information useful to farmers in the separate States, and by other regional reports.

Cooperative seed-treatment tests for cereals and flax, organized under American Phytopathological Society leadership and conducted cooperatively by 11 experiment stations, including 3 in Canada, and the Department, involved especially the possibility of reducing dosages and the value of new organic dusts as seed protectants. The findings that the dosage of New Improved Ceresan can be reduced from one-half to one-fourth ounce per bushel with little loss in benefit, and that seed treatment gives benefits in protecting against soil fungi as well as those borne on the seed should prove helpful to farmers over a wide area.

A series of tests along similar lines involved 32 experiment stations, including 2 in Canada, the object in this case being to determine the value of seed treatments for 10 kinds of vegetables. Cooperative corn seed treatment tests are in progress among 14 State stations and the Department, and work with peanuts to determine the value of different chemicals as seed protectants is under way in about 10 States.

Of major importance is the fact that all of the stations have cooperated effectively with the Department in bringing together basic production information for use in determining production goals. In the 1943 national study of the maximum possible output of farm products, with estimates of the labor, machinery, and supplies needed to achieve this output, station specialists in several subject-matter fields worked with representatives of the Bureau of Agricultural Economics and the Agricultural Research Administration by production areas for each State.

MORE AND BETTER FOOD FROM PLANT SOURCES

With more of every kind of food needed, attention must be given to increasing the output of land and labor. Soil productivity must be boosted; better varieties of crops must replace less productive ones; there must be greater efficiency in growing and harvesting; better ways of reducing crop damage from pests and diseases must be discovered and applied.

Research over the years supplied many of the answers to questions on how to step-up yields. Certain immediate pre-war developments came just in time to play an important part in the war food effort. Other problems had to be solved at the moment.

The Victory Garden program is a good example of how accumulated findings of the experiment stations were put to work to help food production in every corner of the land. Facts on soil preparation, use of fertilizers, what varieties and when to plant, how to fight pests and diseases, and how to use and preserve the foods produced

were assembled and released by each of the stations, thereby providing needed information applicable to each community as far as possible.

Years of plot work, plant breeding, variety testing, and experience in insect pest and disease control under the infinite range of conditions that occur from Maine to California and from Puerto Rico to Hawaii went into this effort. In helping to spread the gospel of better gardens, station scientists joined hands with extension workers in preparing circulars and news releases, and over the radio, at group meetings, and in many other direct ways. A Nation-wide poll has placed the total number of Victory Gardens in 1943 at 20 million, totaling about 4 million acres with an estimated production of 8 million tons of food.

BOOSTING SOIL PRODUCTIVITY

STRETCHING LIMITED SUPPLIES OF NITROGEN

Because nitrogen is needed for ammunition and is likewise essential in increasing food production, a problem of first importance for research by the stations is that of determining how maximum benefit can be obtained from available sources of nitrogen.

Farm manure as a source of nitrogen has been stressed by many stations. For example, the West Virginia station points out that the 8 or 9 million tons of manure produced in the State each year by farm animals contains more than 10 times the nitrogen purchased annually by West Virginia farmers. Careless handling and distribution of manure can easily result in a loss of at least 50 percent of the nitrogen and thus greatly reduce the fertilizing value.

The finding of the Colorado station, that 80 tons of manure spread over 20 acres at the rate of 4 tons to the acre produces larger yields than 80 tons spread over 10 acres at the rate of 8 tons per acre, offers a timely suggestion for obtaining the greatest benefit from limited supplies of manure.

Poultry manure is objectionable because of its odor and its propensity for attracting rodents and insects, and breeding pathogenic bacteria. Experiments at the New Jersey station show that the application of lime nullifies these drawbacks, and, in addition, retards to a great degree the natural loss of nitrogen. Since about one-half million tons of poultry manure with a fertilizing value of approximately 1½ million dollars is produced in New Jersey the discovery of how to save the greater part of this vital material is important in the war emergency.

Manure and legume crops as well as different organic materials, when used in addition to fertilizer to provide nitrogen, have proved effective in increasing yield of vegetable crops in different sections of the country.

In the southeast, the Alabama station found that plowing under legumes plus manure gave the highest yields of fall vegetables. Applications of 1,000 pounds per acre of a 6–10–6 fertilizer with manure increased yields 100 to 300 percent over yields obtained with 1,000 to 2,000 pounds of fertilizer alone. Legumes turned under and 1,000 pounds of fertilizer gave increased yields of 100 to 200 percent over 1,000 1,500, and 2,000 pounds of fertilizer alone. Double amounts of manures and fertilizers gave 25 to 50 percent higher yields than single

amounts. Yields of fall potatoes were increased about 50 percent by addition of manure, and 17 percent by turning under winter legumes.

On sandy soils in the northeast, the Connecticut (State) station found that sheep manure, dried cow manure, and tobacco stems, used in addition to commercial fertilizer, resulted in an average increase of 27 percent in yield of cabbage, sweet corn, and carrots as compared with fertilizer alone.

Legume crops play an important wartime role in providing nitrogen needed for field-crop production. In Alabama, for example, where nitrogen is the limiting factor in increasing production, results from a 17-year study by the station show that by March 25 an average of 4,200 pounds of vetch per acre has been turned annually; by April 5, 6,400 pounds; and by April 15, 7,200 pounds. These amounts of vetch have given average increases of 563, 572, and 659 pounds of seed cotton per acre, respectively. Application of 300 pounds of nitrate of soda per acre increased the yield of seed cotton by 696 pounds. The average nitrogen cost of the increase from vetch has been 84 cents per 100 pounds of seed cotton, and from nitrate of soda 86 cents. On the average, a growth of vetch may be obtained by March 26 in central Alabama which will produce a satisfactory yield of cotton, and vetch may be turned as late as April 15 without any decrease in yield from a late-April planting of cotton. The application of these results in farming practice indicates that good yields of cotton can be obtained even though nitrogen fertilizers are limited.

Miscellaneous organic materials for the preparation of artificial manure used as substitutes for nitrogen fertilizers were investigated by the Massachusetts station, and detailed instructions on methods of preparation and use have been provided. Artificial manure prepared from corn stover, oat straw, or leaves and garbage gave marked increases in yield of corn and hay.

More lime has been recommended by the New Jersey station as an indirect means of helping relieve the nitrogen shortage by making soil conditions more favorable for the growth of legume crops and thus helping them take nitrogen from the air. Lime helps the growth of other crops by making the supply of plant nutrients in the soil more available.

Where soils had been limed and legumes grown, the Missouri station obtained from 10 to 20 bushels more of corn per acre the following year than where corn followed grass or a grain crop.

MORE EFFICIENT USE OF FERTILIZERS

Rates of nitrogen, phosphorus, and potash in the fertilizer and methods of application for various crops have been studied extensively by the experiment stations. At present attention is directed to determining whether current rates and methods of application are the most satisfactory for meeting wartime demands for maximum production.

Saving phosphorus in potato production.—A saving of approximately 25 percent in transportation of fertilizers for potatoes and labor of application has resulted from the finding of the Maine station that the phosphoric acid requirement of potatoes is less than that heretofore thought necessary. In long-time potato-production experiments the station found that a 400-bushel-per-acre crop of potatoes absorbs about 120 to 160 pounds of nitrogen, 120 pounds of phosphoric

acid, 200 to 260 pounds of potash, 35 to 60 pounds of calcium oxide, 20 to 30 pounds of magnesium oxide, and 10 to 12 pounds of sulfur.

Deep placement or plowing under of fertilizers and use of fertilizers in liquid form have proved particularly significant during the present demand for increased production. Under soil conditions where corn yields are from 50 to 60 bushels per acre, the Indiana station found that an increase of 15 to 20 bushels may be expected under favorable conditions from plowing under the equivalent of 400 pounds per acre of 10–10–10 fertilizer on the plow furrow in addition to row fertilization. This increased response from deep placement of fertilizer suggests the possibility of obtaining large yields on infertile soils as well as increasing yields from better soils. The station estimates that the farmers of the State could produce 85 million bushels more of corn and 32 million bushels more of wheat, oats, and soybeans, as well as similar figures for other crops, without plowing up more land and without greatly increasing the labor load.

Plowing under fertilizers was found effective in obtaining increased yields of vegetables in the important vegetable-producing areas of the northeast. A 2-year study at the Pennsylvania station involved plowing under fertilizers in bands, which was found to be the best method for tomatoes, sweet corn, and carrots when total yields are considered.

Fertilizers in water continued to produce more efficient growth of vegetable crops than dry fertilizers in experiments at the New Jersey station. Yields of tomatoes, sweetpotatoes, lima beans, sweet corn, celery, and peppers were increased by the use of fertilizers in water as starter solutions for setting plants and sowing seeds. Applications of fertilizers in water were also found to be more efficient for such long-season crops as tomatoes, sweetpotatoes, and celery.

Under Montana conditions, one of the problems has been the finding of practices that could make possible the production of tomatoes, peppers, and onions, which require a much longer period than the usual 90-day growing season. Fertilization and transplanting methods have been developed by the Montana station so that these crops can be produced. Tomatoes and peppers require 60- to 70-day-old transplants, grown in individual pots. The application of fertilizers from the beginning was more effective than starter solutions or field fertilization where each was practiced alone. Phosphorus and nitrogen were found to be of greatest value.

Byproduct materials as fertilizer substitutes.—A cheap and readily available byproduct, molten calcium silicate slag, obtained from the electric-furnace reduction of rock phosphate in the production of pan phosphorus, as carried out in Tennessee Valley Authority operations at Wilson Dam and by industrial concerns, had little or no usefulness; but by quenching the molten slag with jets of water it was shattered into fine particles which the Tennessee station, cooperating with T. V. A., showed to be useful in supplying to crops both lime and phosphorus.

In the face of a shortage of fertilizers due to transportation difficulties in wartime, the Puerto Rico University station proved that filter press cake, a refuse from sugar mills, was valuable for replacing a part of the usual fertilizers. When applied at the rate of 12 tons per acre plus 1,000 pounds of mixed fertilizer, the cake resulted in significant increases amounting to some 20 percent in tomatoes.

BETTER USE OF SOIL RESOURCES

More intertilled crops, particularly corn and soybeans, are needed to increase the output of agricultural products such as oil and pork. Because of the erosive nature of these crops, any expansion of the acreage should be related to the physical characteristics of the land. Thus, studies by the Iowa station indicate that any increase in intertilled acreage should take place only in certain parts of the State, whereas a decrease is actually desirable in others, unless the use of such practices as contour farming becomes widespread.

A new soil survey, conducted by the Tennessee station in cooperation with the Department, lays a foundation for effective land use planning. About 6 million acres of the State have been already covered in this survey. A program involving study of soils, crop rotations, and fertilizers—the latter in cooperation with T. V. A.—is making possible more effective wartime use of soil and fertilizer resources to produce higher yields and better-quality crops and pastures.

Crop sequence has been found an important factor for obtaining maximum yields of certain crops. Thus, field experiments by the Michigan station have shown a marked improvement in sugar beet yields where beets follow alfalfa or clover or a sweetclover green-manure crop, as compared with growing sugar beets after corn, beans, or wheat. Application of this finding is of timely importance, since such a cropping sequence has seldom been recommended in the past.

Mineral deficiencies frequently limit effective use of soil areas by preventing good plant growth. Recent advances in knowledge of plant nutrient requirements as well as the nature and extent of nutrients in the soil have been made by many stations working on problems peculiar to their own States. Under Florida soil conditions, where mineral deficiencies have caused considerable difficulty both in plant and livestock production, investigations have shown that applications of minor elements to the soil greatly increased the growth of such pasture plants as Dallis, carpet, Bermuda, and Bahia grass, when they were supplied in addition to lime and complete fertilizer.

Another case of soil deficiency is illustrated by results from the California station where the olive dieback disease, characterized by rosetting and dieback of the twigs, yellow leaf tips, low yields, and monkey-face fruits, is a limiting factor in the production of olives in parts of the State. Preliminary limb-injection tests by the California station in 1941 proved that boron produced a remarkable recovery. This discovery was further corroborated by injection, spraying, and soil-amendment treatments in 1942, the recovery of treated limbs or trees being very striking. As a result, about 50 tons of borax have been purchased by growers, and it is expected that about half of the 4,000 acres of olives in Butte County will benefit from boron treatment.

Use of boron, zinc, copper, and green manure by the Alabama station gave 10- to 20-percent increased yields of peanuts.

Soil and crop studies by the Delaware station show that, while some of the soils of that State may be deficient in boron, manganese, sulfur, and zinc, these minor plant foods should not be used generally. For most crops on most soils high-priced fertilizers containing all the so-called minor elements will not increase yields over ordinary fertilizer mixtures.

Soil conservation increases farm production.—As a practical illustration of the contribution of soil-conservation and soil-improvement practices for increasing yields and maintaining maximum production, results from the Wisconsin station and the Soil Conservation Service present the following contrasting picture of a badly eroded and run-down farm operated as an experiment station under a program of soil conservation since 1933. In 1933, the best the farm could do was to support 10 milk cows, producing 1,300 pounds of butterfat; 4 heifers; 4 horses; and a few hogs. The animals were in poor shape because the feed supply was not sufficient or good enough to feed them well. In fact, during the first 2 years of the farm as an experiment station the stock had to be cut down to 6 cows and 2 horses in order to do a good job of feeding, and even then it was necessary to buy feed. The farm land now supports 21 milk cows, with an annual butterfat production of over 4,000 pounds; 4 yearling heifers; 6 calves; and 2 horses—and does it well, without the help of any purchased feed.

While the above results illustrate the long-time benefits of soil conservation, there are also practices that have an immediate effect on crop yield. For example, according to results from the South Dakota station, yields of small grain taken over a 3-year period to compare contour farming and noncontour farming showed a 6-percent increase due to contouring. Likewise, grain sorghum grown as a listed row crop gave an average increase of 19 percent.

BETTER VARIETIES FOR PRODUCER AND CONSUMER

NEW FRUITS AND VEGETABLES

Because fruits and vegetables combine in an unusual manner health-promoting qualities with actual food values, these crops are highly important in the effort to supply food for military and civilian needs. However, because of their perishable nature and bulk, most fruits and vegetables are difficult to transport. Hence, in the war period there has been an unusual effort to increase local supplies of these materials. The stations have played an important part in providing varieties adapted to particular localities and environments.

New fruits for special uses.—Due to occasional periods of extremely low temperatures and frequent desiccating winds both in summer and winter, the North Central States have been unable to grow successfully the standard varieties of apples and pears adapted to the eastern part of the country. In 1943 the Minnesota station released two new apples as distinct additions to the limited materials available in the north-central region. The new varieties, named Victory and Fireside, both possess desirable tree and fruit characters. In addition, the station released the Burgundy strawberry, a new productive variety characterized by an attractive deep red color, large size, and high-quality fruit. This new variety will help provide small fruits for the people of the State and surrounding region.

The New York State station has produced several promising varieties of red raspberries that combine good quality and yield with disease resistance. Milton, the most recent introduction, should help

to increase supplies of this useful and desirable fruit and make raspberry production a safer enterprise in New York and adjacent areas.

New tomatoes.—Because the tomato is one of the most valuable vegetables of especially high nutritional importance due to its content of vitamins, increased production of this crop during wartime has been stressed. No vegetable has wider uses, being in sharp demand in the fresh, canned, and preserved state, and well adapted for combination with many other foods. As a native of the subtropics the tomato is inherently at home in a long growing season without frosts. For the more northerly regions of the United States it is necessary to develop varieties which mature enough of their fruit in the short summer season to make them worth while.

Chatham, a new variety produced by the Michigan station, ripens its fruit at least 1 week earlier than Earliana, the standard for early varieties, and therefore is adapted for gardens in the northern portion of the State. The fruits, though relatively small, are desirable in shape, color, and edible qualities, and promise to fill a gap in the food requirements of northern people. That the Chatham tomato has real merit in other northern localities was indicated by trials at the New Hampshire station where this variety, together with New Hampshire Victory, an early variety bred by the New Hampshire station, showed real merit as an early maturing tomato.

A primitive form of tomato that has marked resistance to several diseases was used as one parent and varieties having good horticultural qualities as the other parent by the Missouri station to evolve new tomatoes that are practically immune to fusarium wilt and also highly resistant to the leaf mold fungus. Such resistance is important in the midwest where climatic conditions of midsummer favor disease development.

The Bounty tomato, bred by the North Dakota station for the short growing season in that State, helped to relieve the food situation in Hawaii when introduced by the Hawaii station with other new varieties of vegetables from the mainland. Strangely enough the variety thrived in Hawaii, setting fruits freely under subtropical conditions and providing Hawaiian growers with a productive tomato.

A new pepper, Truhart Perfection, developed by the Georgia station, is more productive than the original Perfection variety and yields fruits more uniform in size and shape and more attractive in color. This new pepper is timely and important in view of the fact that peppers have been shown by the New Mexico and Rhode Island stations to be valuable sources of vitamin C and other nutritive elements essential to human welfare.

Improved types of paprika are being bred by the South Carolina station. Seeds obtained from Yugoslavia just prior to the war were grown, and desirable types selected therefrom were further improved by crossbreeding. Some of the new strains possess mild flavor, good quality, and bear desirable-shaped fruits. These new paprika varieties are helping to give the Nation a supply of this desired condiment, formerly obtained almost entirely from abroad.

Sweet corn, one of the most valuable vegetables for use in the fresh state and for canning, continued to receive attention by station plant breeders. For example, the Connecticut (State) station announced

during the year the successful development of a whole succession of yellow hybrid sweet corns, beginning with the very early Spancross which matures several weeks before Golden Cross Bantam. In addition to desirable eating qualities these new Connecticut sweet corns possess marked resistance to the bacterial wilt disease known as Stewart's disease. The succession of varieties extends the season of sweet corn to the consumer and aids materially in solving the food-supply problem in Connecticut and nearby localities.

With Golden Cross Bantam and some of the desirable new hybrid sweet corns often failing to ripen satisfactorily, the Maine station had the definite problem of developing varieties that were adapted to the State, which is one of the important sweet corn canning areas of the country. The station originated several new hybrids that met the essential requirements, and in collaboration with the Maine Canners' Association produced some 1,200 bushels of hybrid corn seed in 1942. Because of early maturity, productiveness, and uniformity, the hybrids were decidedly acceptable to the growers and the canners.

New beans developed by the Virginia station, and designated as the Virginia Victory Series, are considered a real contribution toward increasing the home food supply. Infection by the bean rust fungus is one of the limiting factors to successful bean production in Virginia. For a number of years the Virginia station worked on the bean rust problem from the fundamental standpoint of developing resistant varieties and now has released this group of outstanding pole beans to aid commercial, truck, and home gardeners in the food-production campaign.

A new head lettuce, Great Lakes, selected by the Michigan station from seed stocks grown in California by the Department gives promise of making possible the production of satisfactory head lettuce in Michigan. The Great Lakes lettuce is not readily affected by tipburn, a serious trouble of head lettuce in general, and also is slow to form seed stalks at temperatures that favor seeding in the usual varieties of lettuce.

These are not all of the contributions coming from the State experiment stations but exemplify the useful work that is going on to supply the Nation with more and better varieties of fruits and vegetables.

NEW FIELD-GROWN VARIETIES OF FOOD CROPS

New potato varieties characterized by high yields, resistance to diseases, and insects, adaptation to region and season, and superior table, market, and manufacturing qualities are essential to meeting the wartime demands for this important food and starch crop (goal of 3,260,000 acres and 407,700,000 bushels in 1943).

Kasota, a midseason potato introduced by the Minnesota and Nebraska stations and derived from a cross between Bliss Triumph and a seedling selection, has attractive broadly roundish, smooth, medium red tubers maturing in midseason; closely resembles Triumph in cooking quality both in flavor and mealiness; has shown considerable resistance to fusarium wilt; and endures heat very well, survives drought better than most varieties, and is well adapted to locations favorable to a midseason variety, being especially promising in the Red River Valley (of the north) and very satisfactory under irrigation in Nebraska.

Mohawk, a new potato introduced by the New York (Cornell) station, cooperating with the Department, and originating as a cross between Green Mountain and Katahdin, is a fine-shaped, excellent table potato for eastern growers. The tubers are long, smooth, and free from many common tuber defects; are high in starch content; have the high market quality of Katahdin; and when baked are as mealy and good flavored as Green Mountain. Besides being resistant to mild mosaic and moderately resistant to tipburn, flea beetle injury, and hopperburn, Mohawk has been very productive and has outyielded other good varieties in percentage of U. S. No. 1 grade tubers.

The Pawnee potato, a rapid-growing variety developed by the Colorado experiment station and the Department by crossing Rural New Yorker and Katahdin potatoes, is very promising for both the early and late crop in the Greeley district. Pawnee matures early enough so that it can be harvested before sugar beets, and its vine growth is rather small so that late spraying to combat flea beetle damage is more feasible. The tubers are of better appearance than the leading commercial varieties grown in the Greeley district and have good keeping quality in storage, and cooking tests show a high quality for the table.

These are but a few recent examples of the new and promising productions of the national potato-improvement program in which the Department and the experiment stations cooperate as a major war effort.

New sweetpotatoes high in carotene (provitamin A) developed by the Louisiana station include the two seedlings, 1 × 6–39–10 and 1 × 42–39–3, which have proved superior to the Unit 1 Porto Rico introduced earlier by the station. The new seedlings have a carotene content after dehydration of 207.5 and 120.5 milligrams per gram, respectively, as compared with only 97.5 milligrams for Unit 1 Porto Rico. The 1 × 6–39–10 also is more uniform in shape and grades out 50 percent more No. 1's than Unit 1 Porto Rico. The station has increased the two new seedlings as fast as possible at the request of the Quartermaster Corps, primarily because of their carotene content. The Quartermaster Corps has specified Unit 1 Porto Rico as the chief source of seed for dehydration stock and samples of material sent to them in 1942 in connection with this research resulted in contracts for 2 million pounds of dehydrated sweetpotatoes. This proved so satisfactory that 52 million pounds were specified for 1943. This research indicates that although hybridization is the most feasible means of increasing the carotene content of sweetpotatoes, it may be changed materially by environmental factors and cultural practices.

Other sweetpotatoes high in carotene released to growers include two orange-fleshed mutants, by the Kansas station, Nancy Gold and Orange Little Stem which contain 207 and 260 percent, respectively, more vitamin A than Nancy Hall and Little Stem Jersey, the parent varieties.

Better wheats, brought forth by the experiment stations, are aiding farmers in meeting increasing demands for foodstuffs. High yields of good sound grain are needed and the wheat must produce flours that will make satisfactory bread and pastries. Resistance to diseases and insects and endurance to drought are other varietal factors of importance in attaining and surpassing the 52,500,000 acres or the 651,000,000 bushels of wheat goals set for 1943.

Fairfield, a new soft winter wheat developed by the Indiana station, was made available to Indiana farmers for planting in 1943 as a contribution to the war effort. It is definitely superior to all common varieties in its class and combines the good milling and baking qualities and loose smut and mosaic resistance of Fulhio with the high yields, resistance to winter killing, and suitability for combine-harvesting of Purkof.

Pawnee and Comanche are new productive red winter wheat varieties released by the Kansas and Nebraska stations and the Department. They will be available for commercial planting in reasonable quantities in the fall of 1943 and should increase the dependability of the crop of Kansas, the leading wheat State. Pawnee is highly resistant to loose smut, a disease of increasing severity in Kansas in recent years; moderately resistant to bunt and leaf rust; slightly resistant to or escaping stem rust damage; and resistant to hessian fly in certain areas; and is nearly equal to Turkey in milling and baking qualities. Satisfactory for a bread wheat, Comanche combines good milling and baking quality and other good characters with high resistance to many races of bunt, resistance to leaf rust, and tolerance to stem rust.

New spring wheat varieties are also helping in reaching and exceeding the 1943 wheat goals.

Newthatch spring wheat, developed by the Minnesota station in cooperation with the Department, is an early high-yielding beardless variety with strong straw. It resembles Thatcher wheat closely and has the additional desirable feature of resistance to leaf rust as well as stem rust. Newthatch was increased in 1943 and recommended for distribution to farmers in Minnesota, whereas Thatcher was withdrawn from the recommended list.

Rival and Pilot, developed by the North Dakota station and the Department, were given only limited acceptance in 1939 and were regarded as supplements to Thatcher until 1941 when severe leaf rust injury to Thatcher brought them to the fore. The planting of about 2½ million acres in 1942 added an estimated 10 million bushels to the spring wheat crop of North Dakota over the possible Thatcher yield. These varieties are expected to occupy more than 50 percent of the common wheat acreage in eastern North Dakota in 1943 and also extensive areas in Minnesota and South Dakota. They are productive, moderately resistant to stem and leaf rust, resistant to bunt and loose smut, and the equal of Thatcher in milling and baking quality.

Carleton and Stewart, two new superior durum wheats selected from crosses of Mindum with Vernal emmer by the North Dakota station in cooperation with the Department and released to growers in 1943, surpass Mindum in resistance to black stem rust and compare favorably with that durum variety in macaroni color. Carleton is also more resistant to lodging than Mindum or Stewart. The contributions of these new wheats to the food goals lie in insurance against crop loss by stem rust, easier harvesting, and better color of manufactured products.

Dry beans, a food in great demand for armed forces and civilian uses, were making a record crop on a record acreage with prospect of attaining the 1943 national goals of 25,542,000 bags of beans on 3,300,000 acres. Superior varieties and improved production methods, timely products of station research, were major factors in the record crop.

Great Northern and Red Mexican beans that are productive and resistant to the destructive mosaic and curly top diseases are the outcome of 15 years of research by the Idaho station. The fact that station selections of these varieties have averaged over 17 and 6 bushels, respectively, more per acre than common varieties of the group is evidence of their merits. Since practically the entire field bean acreage of Idaho, a leading bean State, is planted to the station's selections, the additional volume of beans for wartime food resulting from these investigations represents a substantial part of the total national production.

Pinto bean strains, improved selections released by the New Mexico station in bean-growing districts in northeastern New Mexico, are considered better adapted than soybeans in these areas. The New Mexico breeding program has resulted in the registration and certification of 172,000 pounds of pinto beans. The Idaho station also has made progress in breeding disease resistance into pinto beans and garden varieties as well.

New sugarcane varieties, suitable for mechanical harvesting, a factor of current importance because of wartime labor shortage, and adapted to definite growing areas, have been released by the Louisiana station, the Department, and the American Sugarcane League. C. P. 33–310, promising for the terrace soils of Lafayette and adjoining parishes in Louisiana, is resistant to mosaic and has a relatively small diameter and erect growth which should make it well adapted to mechanical harvesting. C. P. 33–425, also suitable for machine harvesting, requires the most favorable soil conditions in the Red River section and on the better-drained soils of the upper Mississippi area, and may thrive on reclaimed muck in Lafourche Parish. These canes are timely examples of the precise adaptation of crops in limited conditions, the results of intensive study and careful breeding and testing.

BETTER WAYS OF GROWING AND HARVESTING FOOD CROPS

NEW AND BETTER PRACTICES

The discovery of measures which tend to increase yields of food crops, help to improve the quality of the product, or prevent losses in storage is worth while in peacetime and especially valuable in wartime, when maximum production of high-quality products is particularly important.

More tomatoes for Michigan.—A simple cloth-covered frame devised by the Michigan station for growing tomato plants prior to setting in the field has helped to increase tomato production. The frame is built with slatted sides and banked with fresh manure which affords protection and at the same time provides considerable heat for the young plants. When compared with plants purchased from southern sources the frame-grown plants were superior in survival and in one test yielded nearly 7½ tons of marketable fruits per acre as compared with about 4½ tons for the southern plants. The home-grown plants had the added advantage of being available for setting whenever weather conditions were most favorable.

Irrigation of vegetables in Kansas.—In a study of different systems of irrigation, the Kansas station found that overhead spray irri-

gation increased yields of late spring, summer, and fall vegetable crops 59.2 percent more than where no irrigation water was applied. Using the same amount of water, the comparative percentage increases for other systems were 54.8 for rotary spray irrigation, 45.8 for furrow irrigation, 37.2 for perforated pipe, and 34.2 for subirrigation.

Onion seed increased by autumn planting.—The finding by the Idaho station that autumn-planted onion bulbs of hardy varieties produced more seed the following summer than bulbs set out in the spring following storage is timely because of the greatly increased demand for vegetable seeds by commercial and home gardeners. Large bulbs produced more seed than small bulbs. New Mexico station studies showed that fall planting of onion bulbs likewise is best for seed production in New Mexico. August planting eliminated the necessity of winter storage of bulbs and reduced losses from bulb rots. Pink rot losses were reduced by planting bulbs on ridges, a type of culture which increased seed production about three times over that obtained with the standard method of level planting.

Saving time in carrot-seed production.—With large quantities of carrots needed quickly by the armed forces and civilian populations both at home and abroad, the finding by the New Mexico station that carrot seed can be produced in only 1 full year instead of 2 seasons is especially timely. The "overwintering-in-the-field" method of growing carrot seed is both quicker and less costly than the conventional method since harvesting and replanting the carrot roots is eliminated. Moreover the storage problem involving cost of storage and losses due to rot is also avoided.

Fruit drop reduced by new practices.—That boron under certain conditions may be an important factor in reducing preharvest drop of McIntosh apples was indicated in experiments conducted by the New York (Cornell) station. On 20-year-old McIntosh trees which showed a tendency to produce corky apples the amount of drop before and during harvest was considerably less where the soil beneath the trees had been given a moderate application of borax.

At the Massachusetts station preharvest sprays proved more effective than preharvest dusts containing the same active ingredient for reducing the drop of McIntosh apples. Since the materials used in preharvest treatments are costly and in view of the shortage of fruits in the war period, this information had value to the growers both in saving money and in increasing the supply of marketable fruit.

The California station in cooperation with the Department found that preharvest sprays may reduce the dropping of Bartlett pears to about 50 percent of that of untreated trees. In one instance where naphthalene acetic acid was used the drop was reduced nearly 70 percent below that of the checks. Obviously these material reductions in the percentage of dropped pears were of great benefit to the grower and the consumer. The success of preharvest sprays for reducing dropping of fruit has been shown by several of the stations to vary greatly with varieties and with prevailing climatic conditions.

Delayed harvesting of fruit.—As a practical means of obtaining increased production of fruit, the Washington station found that fruits left on the trees until canning-ripe not only increased in size but had better quality when eaten. Apricots, for example, increased

16 percent and Elberta peaches over 35 percent in weight between the shipping stage, when fruits are ordinarily picked for distant markets, and the canning stage of maturity. Soluble solids, including sugars, were increased markedly during the period between early and delayed harvest.

The washing of fruits proved a serious problem to growers of the Pacific Northwest when faced with a labor shortage at harvest. Ordinarily, apples and pears are washed prior to storage to remove excessive spray residues. Fortunately the Oregon station discovered that apples could be stored safely without removing the spray residues provided the fruit was kept dry during harvesting and storage. Later the fruits were washed before packing for shipment. Fruits sprayed with both copper materials and lead arsenate kept better in the unwashed condition than did those which had been sprayed with arsenates alone.

Apple cartons made of a weatherproofed grade of corrugated paper proved satisfactory substitutes for wood packages in tests by the Indiana station. With wooden containers in short supply and high in price, this finding promised to be of service in handling the 1943 crop of apples.

Solving labor shortages in cranberry harvesting.—An effective contribution to solving the labor problem in the cranberry districts of the State has been made by the New Jersey station. Experiments over an 8-year period proved that scooping instead of hand-picking the berries is not injurious to the vines. Although 90 percent of the berries were harvested by hand-picking as compared with 80 percent by scooping, the station showed that at least half of the missed berries could be recovered as floaters by flooding the bogs. By adopting scooping New Jersey cranberry growers have avoided possible rotting of their crops on the vines because of labor shortages.

Longer storage life for fruit.—Studies by the Iowa station upon ways and means of improving the keeping of the Delicious apple, one of the important commercial varieties, showed that the storage life could be prolonged by placing the fruit in an atmosphere made up of 2½ percent oxygen and 97½ percent nitrogen and maintained at 32° or 40° F. The onset of the mealy condition, characteristic of overmature Delicious apples, was definitely retarded in the modified atmosphere, thus prolonging the effective use period for this desirable apple. There was no significant effect on flavor or quality as a result of the treatment.

At the Maine station it was found that a modified atmosphere containing 5 percent or less of oxygen and maintained at 41° F. preserved blueberries better than did ordinary air storage, thus extending the market and use season for this desirable small fruit which ripens generally during a short period and often floods the market with consequent wastage and low prices.

Storage losses in winter squash reduced.—Squash is an important winter food in New Hampshire, helping materially in balancing the food supply of farm and city people. Studies by the New Hampshire station of factors involved in storage losses of squash showed that the common practice of field piling and covering to prevent frost injury is distinctly harmful. Direct removal from the field to storage was much the better practice. Apparently small wounds

caused in the skin of squashes in the piling and handling operations opened the way for serious infections that later rotted the squash during storage.

Success with sweetpotatoes, a crop of increasing national importance during the war emergency (goal of 1 million acres in 1943) for starch, food, and feed depends largely on efficient production methods. In studies of the Mississippi station, cooperating with the Department, highest total yields and greatest net profits per acre were obtained with Triumph, a good starch and feed type, from early planting, and hills spaced 16 to 24 inches apart; and with Porto Rico, a food variety, from 16-inch spacing. Net profits as well as acre yields dropped with delay in date of planting, and with wider spacing when mule or tractor equipment methods were used. Proper fertilizers, efficient plant production, and still other factors essential for success on sweetpotato farms have been determined by the station. Sweetpotato starch manufacture is a new industry in the United States, and the only plant for this purpose is located at Laurel, Miss. Many problems of manufacture have been solved and others are under study.

The New Jersey station reports from its extensive research that substantial yield increases may follow certain practices, including the use of starter solution on plant beds after the first plants are pulled, choosing good-sized vigorous plants and setting them with a starter solution, keeping dry fertilizer away from the roots, applying from 300 to 500 pounds of pulverized magnesium limestone per acre in the bottom of the plowed furrow on soils with a pH of 5.0 or less, mulching on gravelly or light sandy soils, and harvesting after September 20.

Sweetpotatoes, along with muskmelons, watermelons, and other food crops, are grown on Buckner coarse sand in the Muscatine Island district of Iowa, an important Corn Belt truck area. Here, the Iowa station has obtained highest yields of U. S. No. 1 sweetpotatoes from 15-inch spacing of plants in 3.5-foot rows and from planting in late May. With overhead-sprinkler irrigation growing the crop on the level was as satisfactory as ridge culture. A 3–9–18 fertilizer at 500 pounds per acre produced as high yields of U. S. No. 1's as did larger applications.

Field beans in Michigan in the 1942 crop amounted to 6,024,000 bags (100 pounds uncleaned), and still greater production was asked for 1943. Research of the Michigan station was helping bean growers of the State in the special problems involved in attaining the goal of 800,000 acres requested. Michelite, the variety developed and recommended by the station, is disease-resistant, easier to harvest, entails less screening loss, and is superior in quality and appearance. Good soil preparation also has been shown by the station to be effective in maintaining high yields. Sweetclover seeded in fertilized small grain and plowed under the next spring when 8 to 12 inches high has been the ideal forerunner to a good bean crop. Good returns follow the use of 150 to 300 pounds per acre of 0–16–8 or 4–16–8 fertilizer applied in a band about 1 inch to the side of and from 1.5 to 1.75 inches below the seed. Other practices conducive to high yields and quality have been developed by the Michigan and other stations in bean-growing States.

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Weed control in crop and truck lands cuts out an important obstacle to attainment of production goals, saves labor and power, enhances market grades of products, and raises land values. Station research aimed against weeds was providing farmers with effective control measures.

Field bindweed, for example, as determined by the Minnesota station and the Department, could be eradicated in from 2 to 3 years by a full season of cultivation (about every 2 weeks) with a duckfoot cultivator, followed by rye or winter wheat sown about September 15. The grain was removed as early as possible and cultivation resumed. The grain also has been grazed successfully with sheep until June 15. Cultivation of bindweed-infested fields until July 1, followed by a summer competitive crop, such as Sudan grass, millet, sorghum, and soybeans, also proved effective. In 1936 when the research was initiated, infested farms were liabilities, while today the same farms are eligible for loans and these practical control measures have added millions of dollars to the value of infested farms in Minnesota. Substantially similar results have been obtained in Kansas, Nebraska, and Idaho, the details as to crops and their management, however, being somewhat different.

Sodium chlorate, found the best chemical for eradicating long-lived perennial weeds in the Minnesota station studies, was most effective when applied in the late summer or early fall and at the rate of about 500 pounds per acre. Mustards, wild radish, wild buckwheat, and ragweeds were killed by Sinox, a proprietary compound with a sodium salt of dinitrocresol as its principal ingredient. Crabgrass, dandelions, and mouse-ear chickweed were destroyed by spray applications of 0.5 gallon of water-white kerosene (color Saybolt 23) to each 100 square feet.

Onion and carrot growers in California have applied short cuts in weed control developed by the California station to large areas of these crops so important in the war effort. Weeds in carrots are controlled by stove-top oil at a cost of $8 to $10 per acre, whereas hand weeding formerly cost about $60 per acre. Sinox has been effective in controlling weeds in young onions and garlic—acre costs of hand weeding these crops have amounted to from $30 to $40. Acreages of carrots and onions have been increased greatly, and estimates are that in 1943 about $100,000 worth of these crops were saved through the use of selective sprays.

Nutgrass may be eradicated and a cash or feed crop grown each year, the Arizona station determined, if the control method developed is carried out promptly and thoroughly. Spread in transplant material from infested nurseries and in water from ditches, nutgrass (*Cyperus rotundus*) by competing with crop seedlings for water reduces the stands, particularly in crops planted between May and November on infested areas. Drying nutgrass tubers by bringing them within a few inches of the soil surface through successively deeper plowings at intervals of from 2 to 3 weeks during the hot months, followed immediately by a sorghum smother crop, has successfully controlled nutgrass in fields. The soil should be kept dry during the plowing treatments. Two or three hoeings in the sorghum row usually hastened eradication very materially, and weekly cuttings, it was found, would kill the weeds in moist soil. Continuous cultiva-

tion, a practical method of eradication from permanent plantings, should be carried on for three seasons to kill all the weeds around the trees or vines. Irrigation each month with weekly cultivation has been the most practicable method of killing nutgrass where no crops are to be grown. A cultivator with sharp sweeps, a good disk, and a hand hoe, in order, have been the most effective implements.

NEW MACHINES TO SAVE MAN-HOURS

Obstacles in the way of attaining maximum production, such as shortages of manpower, equipment, and fuels, have been met in part by several stations through the development of new equipment for special jobs and by finding ways of using available material and equipment more efficiently. While work at the stations originates because of problems specific to a particular area or crop, the results frequently are of considerable value wherever a particular crop is grown.

Equipment for shearing and planting sugar beet seed, developed by the California station in cooperation with the Department, represents a contribution having wide significance in meeting the production goals of this high-labor-requirement crop. An estimated 3 million man-hours of labor for blocking and thinning sugar beets were saved in 1943 through widespread use of shearing and planting equipment. Sheared seed was used to plant 1 acre in 1941, approximately 10 acres in 1942, and the station estimates at least 300,000 acres in 1943. Sugar beet processors have built sugar-beet-shearing equipment from plans furnished by the station with the result that sheared seed was available to most growers in 1943. The problem of planting sheared seed was solved by the station through the development of plate planters for two common makes of drills, thus making possible the conversion of drills on hand and avoiding manufacturing restrictions because of priorities.

Investigations of the efficiency of the seed-segmenting operation by the Ohio station showed that the effectiveness could be increased by using a large fanning mill and a specially developed scarifier with the California-type seed segmentor. This resulted in fewer double seeds. The station estimated that 60 to 75 percent of the 1943 sugar beet acreage in Ohio would be planted to segmented seed, thereby greatly reducing hand-labor requirements.

Seed treatment of sheared beet seed was found to be effective in helping to protect sugar beet seedlings against seed-borne *Phoma* or *Pythium* or *Rhizoctonia.* For this purpose the California station used Ceresan or New Improved Ceresan with success.

Mechanical thinning and harvesting of sugar beets reduced the labor requirement from 27 to 2½ man-hours per acre without loss of yield, according to results from the Colorado station and the Department. Hoeing after mechanical thinning of sugar beets was found to require one-sixth less time than hoeing after hand thinning and blocking. A mechanical harvester developed at the station which pulls, tops, and piles the beets for mechanical loading reduced man-hours required for harvesting from 44.8 to 9.4. A further reduction in the labor requirement for the production of sugar beets was made possible by the Michigan station through the development of a mechanical sugar beet loader.

Combining and artificial drying of rice.—Harvesting rice requires a considerable amount of labor with the usual binder-thresher method. Most rice growers have combines for harvesting other grains and soybeans, but have not been able to use this efficient method for rice because of the high moisture content at harvesttime, which causes a serious storage problem and results in greatly reduced milling quality.

The use of improved methods of combining, artificial drying, and bulk handling developed by the Louisiana station have made possible the harvesting of 20,000 barrels of rice with a crew of 8 men which under previous methods required from 30 to 40 men. The combined and artificially dried rice was found to be better in milling quality than that harvested with other methods.

A farm unit drier for combined rice developed by the Arkansas station is proving of considerable value under the conditions in that State, and a simple type of drier developed by the California station is helping California farmers achieve war goals for rice.

A new sled seed planter equipped with fertilizer-placement machinery developed by the Hawaii station for vegetable-seed planting has been valuable in making possible increase in food-crop plantings needed for the islands.

A flame cultivator developed by the Louisiana station in cooperation with a sugarcane planter gave as good or better yields in experimental plots than hand hoeing at only about one-fourth the cost. The saving over hand hoeing was about $2.50 per acre. Use of flame cultivation for the entire 1943 Louisiana cane crop could mean a saving of approximately $800,000 and prevent possible abandonment of acreage because of the extreme labor shortage.

REDUCTION OF LOSSES FROM DISEASES AND PESTS

Of real advantage to wartime production in agriculture is the help which experiment stations are giving the farmer in his struggle with the innumerable plant diseases and insects that take a severe toll from his fields every year. The attacks of crop pests create difficult and discouraging problems for growers; they mean wasted effort, reduced income, and sometimes ruin. In bad years, sweeping epidemics of rusts, blights, mildews, grasshoppers, chinch bugs, and hessian flies may cause almost total destruction of particular crops over wide areas. Every year, however, in less conspicuous manner, plant parasites and pests reduce yields and quality of crops, add to the farmer's costs, and cut his profits. No part of the country escapes. The total damage that results is huge.

To the Nation at war these attacks mean less of the critical war material—food. In the South, for example, the 1⅓ tons of cabbage destroyed by insects on each unprotected acre was enough to make a year's supply for 140 people on the basis of the estimated per capita consumption in the United States. In California the tomato fruitworm ruined as many tomatoes per single acre as would have been consumed by 125 people on the average in a year. In Pennsylvania leaf and stem infections caused tomato production to drop to 1⅓ million bushels in 1942. The same season potato late blight descended on Iowa in the first serious epidemic since 1918. It wiped out potato fields until the losses in yield for the State equaled the average annual consumption of 2⅓ million people. In a single Arkansas county in 1942

mildew destroyed one-third to one-half of the first cutting of spinach on some 13,000 acres.

The difficulty of developing practical methods for crop protection against such enemies is increased by the fact that each disease is caused by a different organism and each insect species is different from all others. Treatment that proves highly effective for one is seldom equally effective for another. Schedules for spraying or dusting, or agricultural practices that are successful in one part of the country or in one season, will not necessarily do the job elsewhere or in another year. Furthermore, new crops, new varieties, new methods of farming, new insects, new biological races, and changing weather conditions all bring new pest-control problems to trouble the farmer and to challenge the resourcefulness of research workers.

It is due in no small measure to the efforts of these investigators in the stations and the Department that, in spite of wartime shortages of manpower, machinery, and materials for pest and disease control, no period in the history of American agriculture has seen such widespread use of effective, up-to-date, scientifically timed crop-protective practices. Never have there been such rapid advances in the development of new knowledge and new materials that give promise of greater future success in preventing crop-pest losses.

Current research in this field also gives promise of overcoming in the years ahead much of the waste of farm products resulting from decay, deterioration, and insect damage after harvest. Illustrations follow which show how experiment station work is helping American agriculture stop the leaks in crop production due to plant diseases and insect pests. They have been selected from a large number of examples reported during the year.

PREVENTING FOOD CROP LOSSES BY PLANT DISEASES

Plant disease forecasting.—By predicting outbreaks of crop pests and diseases on the basis of field observations and study of local weather conditions, experiment stations are able to warn growers in advance as to the time when sprays and dusts should be applied for greatest protection. This type of service is already well established in orchard sections of New York and other States and has helped to maintain high fruit yields and quality.

In the Upper Mississippi Valley, after the disastrous experience with potato late blight in 1942, the State experiment stations organized a regional potato late blight forecasting service as an aid to 1943 wartime production. Current reports were sent from the other States to the Iowa station. There a weekly digest was prepared and sent out. This enabled warnings to be given to potato growers in each State in line with seasonal indications. Great improvement resulted in the timeliness and efficiency of late blight protection throughout the region. In the East, the Connecticut (State), Maine, and other stations also helped growers with a blight warning service.

Plant pathologists in the stations along the Atlantic seaboard have similarly cooperated with each other in following the seasonal northward advance of downy mildew on cucumbers and melons. Resulting forecasts have done much to strengthen grower defense against this infection.

Better control of vegetable diseases, worked out by station research, is bringing greater returns for the money and labor invested in Victory Gardens and in the 3½ million or more acres devoted to commercial truck- and canning-crop production. Vegetable breeding for disease resistance has been a major experiment station contribution to the war production program, but improvements in the use of fungicides and other control measures developed by the stations have also been of value as illustrated by the following examples.

Tomato curly top and leaf disease control.—Topping all other vegetables in the country, tomatoes were grown on over 800,000 acres of good soil in 1942. Tomatoes are highly susceptible to many fungal, bacterial, virus, and nemal infections. Experiment station research has helped the producer to greatly reduce many of the losses caused by them, and every year new information of value is being released. The Virginia station recently announced the superiority of newer fixed-copper dusts over old standard bordeaux spray against leaf disorders, in 2 years of tests; not that they controlled the diseases better but that they did not retard ripening as did the old spray. The Utah station cooperating with the Department found that damage from the curly top virus, the most sweepingly destructive disease of the far West, could be greatly reduced by earliness of planting, direct seeding in the field, and by closer spacing of plants.

Tomato root knot.—Solar heat was used successfully in a farm-scale test by the Texas station to reduce root knot nematode infection in a 40-acre tomato field where this pest had ruined string beans planted earlier. By plowing three times at 7- to 10-day intervals, going 1½ inches deeper each time, the infested soil was turned over and a new layer exposed to full sunshine with the thermometer at 100° F. or above. Part of the field was not so treated. Subtracting the $8 per acre cost of all the plowing, the tomatoes in the plowed area brought an income of $100 per acre more than the stunted plants in the untreated part. Such use of sun heat against nematodes may have wide application. It was no doubt an important factor in the bare summer-fallow method developed by the Florida station for reducing the population of root knot nematodes in the soil. These almost invisible threadworms invade roots and reduce yields of many important food, fiber, and oil crops. It is considered probable that no other single crop pest does so much damage year after year in the southern half of the United States. Root knot is a major obstacle to war production. Preliminary studies by the California station of a new fumigant for its control appear promising from several angles.

Blight-free bean seed.—The Louisiana station found a way to get around bacterial blights of snap beans that frequently ruin whole fields in the mild, moist climate of that State. They arranged in 1942 to secure for Louisiana growers 50,000 pounds of seed grown on the Pacific coast in fields free from the disease. The plan worked. The disease did not start up in plantings made with this seed. Later 95,000 pounds of the certified disease-free seed were brought in. The growing of this important vegetable crop was thus saved with no extra labor and little expense.

Onion yellow dwarf and smut.—The virus that causes yellow dwarf invaded Oregon. In 1941 in a muckland area of several thousand acres this infection hit 90 percent of the crop. Yet in 1942 less

than one-tenth of 1 percent was affected. Through community cooperation, the major reservoir of the virus, the onions kept for seed production, were grown a safe distance of at least a mile away from commercial onion fields. This plan was developed by the Oregon station on the basis of facts about this virus developed earlier by investigations at the Iowa station. The New York (Cornell) station announced the discovery that Catex, an organic product of destructive distillation of southern pine stumps, may be substituted effectively for formaldehyde, critical war material, in preventing another onion disease, the smut which is an annual threat to the State's 2- or 3-million-dollar onion crop.

New fungicides check cabbage and cucumber mildews.—Of all the cabbage grown on more than 184,000 acres in 1942, most of the early supply was produced in the South where downy mildew is a perennial source of disappointment and loss. The disease seemed to defy scientific attack until recently, when the Mississippi station found that benzene fumigation of the cabbage plant beds is effective in suppressing this infection just as it is for blue mold in tobacco beds, and the Florida station discovered that spraying or dusting with Spergon or Fermate will prevent serious seedling damage. Cucumber mildew and insects responded so well to applications of cuprous oxide and cryolite dust in Louisiana station tests that the yields were over 50 percent larger than where standard bordeaux, often injurious to foliage of this crop, was used. The same station issued a special bulletin to help growers in the far South recognize vegetable and fruit diseases common in their territory and to advise them on the best measures thus far developed for their control.

Potato-disease control.—With the increasing importance of potatoes for military, Lend-Lease, and rehabilitation purposes—and the 1943 potato acreage advanced to over 3⅓–million acres, 24 percent above 1942—measures developed by station research to reduce the annual losses from potato diseases take on added significance. A program of copper sprays was worked out by the Texas station against leaf diseases in spring-crop potatoes which are grown on more than 2,000 acres in the lower Rio Grande Valley. These sprays kept the foliage alive beyond the traditional harvest date—90 days after planting. For every additional day the vines were kept healthy, up to 5 bushels more were added to the yield of every acre. Spraying in this area greatly increased the 1943 spring crop and helped to mitigate the serious national potato shortage at that time.

Of wide importance is the proof secured by the Maine station cooperating with the Department in a 5-year investigation that potato refuse piles or dumps are major sources from which serious late blight epidemics may get an early start. Other stations have now confirmed this discovery. Maine, along with other States, has conducted a vigorous campaign to get rid of these local reservoirs of infection.

Over the last 20 years the Maine station has learned that no strains of potatoes can ordinarily be kept free from tuber-perpetuated virus diseases when grown in the open. Perfect protection was found possible, however, by growing the potatoes under aster-cloth which excludes the insects that carry infection. Certain foundation seed-potato stocks are already being maintained in disease-free condition by this method.

Much loss arises every year in many parts of the country from the rotting of potato pieces in the soil. Often large acreages must be replanted. The Idaho station has found that much of this trouble can be avoided by preventing the seed pieces from drying out. After cutting, they are dropped immediately into moist, well-drained soil, or before planting are kept in a moist condition long enough to permit the cut surface to heal or cork over and thus resist bacterial invasion even when soil conditions are not so favorable.

Sweetpotato blackrot and stem rot prevention.—Sweetpotatoes are of such importance to the war production program that an effort was made in 1943 to have close to a million acres planted to this crop, nearly a third more than in 1942. The roots used for producing plants to set in the field are often diseased. The infections spread to the sprouts and are carried on them to the field where they may cause serious loss. Mercurial treatment of the roots, proved out at many stations, has done much to prevent such losses. Mercury is, however, a critical war material. The Mississippi station in testing sodium dinitro-orthocresol as a substitute for the usual mercurial treatment found it highly effective against blackrot and stem rot, also cheaper and quicker.

Rice stem rot damage reduced.—Over 1½ million acres were planted as the 1943 contribution of the rice farmers of the United States to the war production program. This acreage expansion has been encouraged by the discovery at the Louisiana station that on certain soils where stem rot is prevalent, drainage followed by application of ammonium sulfate and acid phosphate greatly decreases the losses. In test plots the yields were increased by this treatment as much as 23 bushels per acre.

FUNGICIDES

Shortages of fungicides create serious problems. A number of stations have cooperatively undertaken to find out how best to check plant diseases when sufficient supplies of fungicides are lacking to carry out the usual recommendations. Results of studies by these stations point to the conclusion that often the best way out is to stretch the active chemical by using it in greater dilution while at the same time taking extra care to cover the foliage completely. Such was the outcome at the West Virginia station, for example, in tests with copper dusts on potatoes and at the Connecticut (State) station in tests with bordeaux spray on potatoes. The use of rather strong formaldehyde has been recommended sometimes for soil disinfection. The Massachusetts station, however, has found that formaldehyde applied in very dilute form to soil in which vegetable seed has been planted controlled damping-off and other seedling diseases cheaply and easily.

Substitute fungicides can sometimes take the place of standard fungicides when the supply runs low. Many new materials have been tested from this standpoint at stations in all parts of the country. Extensive trials have shown that among the more promising newer organic synthetics may be listed ferric dimethyl dithiocarbamate (Fermate), tetrachlorquinone (Spergon), and tetramethylthiuram disulfide (Thiosan or Arasan). The Rhode Island station reports good results with these for dry seed treatment, for dipping potatoes in wet form, and as sprays for foliage protection. Preliminary results

indicate that there are a number of other materials that may prove equally useful for particular purposes.

Fermate topped all other sprays in tests at the Oregon station for the control of peach brown rot blossom and twig blight. It also controlled apple scab and rust at the Connecticut (State) station and was highly effective as a dust for potatoes in Ohio station experiments. The New York State station found it superior for the control of anthracnose on tomato fruits.

Spergon was effective against *Alternaria* blight of tomatoes and also against apple scab and rust in Connecticut (State) station tests. When used as a dip at the Kansas station it protected sweetpotato planting stock from stem rot and increased yields over 35 percent. When used by the California station to treat the strings on which hops climb, Spergon reduced downy mildew attack and increased the yield of hops by 13 percent. The Florida station learned that it controlled damping-off of celery efficiently.

Arasan has proved highly efficient as a seed disinfectant to protect peanut seed from decay or blight in the soil and to promote increased germination in tests in several Southern States. Further exploratory work is going forward to determine the extent of its usefulness.

Thiosan proved to be an effective seed protectant in New Jersey station experiments with beans, lima beans, beets, cucumbers, peppers, radish, and spinach.

PREVENTING FOOD-CROP LOSSES BY INSECTS

Tomatoes are one of the most desirable garden vegetables in Hawaii, being especially prized from a nutritional standpoint and for general utility in preparing meals. In experiments conducted by the Hawaii station the set of tomato fruits was increased 31 percent by applications of pyrethrum dust alone and 89 percent when tetramethyl thiuram monosulfide was added to the dust. These large increases were obtained through control of the tomato bug *Cyrtopeltis varians* (Dist.).

The **tomato mite** in certain seasons is the most serious pest attacking tomatoes in a number of California tomato-growing localities. According to recent investigations of the California station, petunia is apparently the preferred host of this mite and evidence indicates that infestation in a number of cases probably occurred in the seedbeds where the tomatoes were near petunia plants. A dust containing 75 percent undiluted calcium arsenate and 25 percent dusting sulfur gave satisfactory control of the mite and, where properly applied, also proved effective against corn earworm, hornworms, and other caterpillars. Careful field observations have shown that most mite damage occurred where dusting was done too late or where the dust was improperly applied.

Garden bean varieties planted just before or at about the start of the spring migration of the beet leafhopper in certain districts in Idaho nearly always escape injury from curly top disease, according to results of the Idaho station and the Department. Beans planted later are usually severely infected.

Onions differ widely in susceptibility to attack by thrips In trials conducted for the past 10 years by the Ohio station, commercial varieties, such as Southport Yellow Globe, Southport White Globe, South-

port Red Globe, Early Yellow Globe, and Brigham Yellow Globe were most susceptible to attack. Varieties of the Spanish type were intermediate in susceptibility, while White Persian was the least susceptible of any variety tested. Although the White Persian is undesirable as a commercial variety it is being used as a parent in a breeding program.

Potato yields in Wyoming are seriously reduced by psyllid yellows, a virus disease transmitted by the potato psyllid. This insect can be controlled effectively and economically with 325 dusting sulfur, according to results of a 4-year study conducted by the Wyoming station. This dust gave better control than lime-sulfur or wettable sulfur spray of all 3 stages of the insect, adults, eggs, and nymphs, and resulted in both a higher total yield and a higher yield of U. S. No. 1 potatoes.

Strawberries can be transported to new fields and set out without danger of bringing crown borers with them, by means of an inexpensive methyl bromide fumigation developed by the Kentucky station. Crown borers are carried to new plantings in young plants taken from infested mother fields, and the treatment destroys the borers without injuring the plants. In one locality growers are reported to have set out 80,000 plants treated in this manner. In areas where the insect is already established, control is possible through the use of a home-made bait consisting of poisoned dried apple pomace.

Peach trees can be replanted with safety immediately after removal of old trees infested by black peach aphids as the result of research by the Michigan station. Applications of 2 ounces of carbon bisulfide at the apices of an 18-inch equilateral triangle effectively controlled the aphids within the enclosed soil area and permitted the replanting of young peach trees without loss. In untreated soil, the aphid attacks the roots of newly planted peach trees and usually kills them.

Grain fumigation.—With the problem of shipping and storing quantities of grain under varied conditions the question arose as to the effect of modern methods of fumigation for insect control on the baking quality of flour made from such grain. The Kansas station determined that moderate dosages of allyl bromide and chloropicrin did not affect baking quality. Fumigation with cyanide, however, was detrimental to baking quality for a period of about 3 days following treatment.

Insect-resistant sweet corn.—In connection with its program for developing sweet corn resistant to corn earworm, European corn borer, and bacterial wilt, the Iowa station introduced in 1943 two new outstanding types—Iogold Early and Golden Iogent. These will aid in the canning-crop and Victory Garden food-production program. Ioana, a golden hybrid sweet corn introduced by the Iowa station in 1935, is now being widely planted by canners in Iowa and other parts of the Middle West. Because of reduced damage by corn earworm it is being used also in the South. In the winter of 1942, 30,000 pounds of seed were sold in the Rio Grande Valley of Texas. Another Iowa station variety, Golden Inbred 45, in tests at Charleston, S. C., proved to be the most resistant to corn earworm of any early or midseason sweet corn inbred in 1942.

STRETCHING INSECTICIDE SUPPLIES

Wartime shortages of certain insecticides, especially rotenone and pyrethrum, have stimulated research by the State stations to develop

new sources of supply, find substitutes and ways of reducing dosages, or discover combinations whereby smaller amounts of scarce materials will give effective kills.

Rotenone, a widely used insecticide prepared commercially from the roots of plants of *Derris* and *Lonchocarpus*, was formerly obtained chiefly from the Far East. The limited supplies available since the outbreak of war have been restricted so as to insure their most effective use in food production. The Federal Puerto Rico station had the only accessible large source of *Derris elliptica*, and, in order to provide plants for increasing production in the Western Hemisphere the station undertook large-scale propagation of high-yielding strains. In cooperation with the Board of Economic Warfare 634,310 cuttings were distributed to 11 countries in Latin America, and at the end of the year 480,500 cuttings were on hand in nursery beds awaiting shipment. This important service was made possible through previous research by the station on methods of propagation which are being further improved in current studies.

Means of increasing yields and rotenone content of roots of *Derris* were investigated by the Federal Puerto Rico station during the year. Lack of potassium and phosphorus was found to lower root yields. Lack of magnesium definitely lowered rotenone content while lack of sulfur decidedly increased it. Growth at higher elevations tended to reduce rotenone content even though the yield of roots was comparatively high. Thus, roots grown at 50 feet had 6.8 percent of rotenone, those grown at 1,400 feet 4.3 percent, and those at 2,400 feet 2 percent.

The effectiveness of rotenone may be increased by the kind of filler or diluent used in the dust mixture, according to recent studies by the Connecticut (State) station. Pyrophyllite, a talclike form of aluminum silicate, actually increased the effectiveness of pure ground derris root when used in the proportion of 3 parts or more to 1 part of root. Mortality following use of 0.25 percent rotenone with pyrophyllite under laboratory conditions was higher than from 2 percent rotenone with fibrous talc or clay. Thus, 1 part of rotenone with pyrophyllite produced more than eight times the effect that was produced when fibrous talc or clay was used as the diluent. Under field conditions it was found that not more than 0.4 percent rotenone with pyrophyllite was required to produce the same degree of control as that obtained by 1 percent rotenone with clay.

Combining rotenone and nicotine not only gave better aphid control, in experiments by the Wisconsin station, but also gave control with less rotenone. The total killing effect of combinations of these two insecticides, when used as dusts for pea-aphid control, was found to be greater than the sum total of the individual effects of the two component insecticides. In every instance the more effective rotenone-nicotine blends gave better control of pea aphid than 0.75 percent rotenone, which has been the standard treatment for years. On the basis of these results a rotenone-nicotine combination was recommended as one of the three aphid insecticide formulas most suitable for 1943.

Rotenone and pyrethrum dusts gave satisfactory control of the pea aphid in experiments by the Maine station. A dust containing 0.3 percent of pyrethrum was slightly more effective in killing aphids than a dust containing 1.0 percent of rotenone. Peas are an important

canning crop in Maine, and the discovery of a satisfactory control for this destructive insect pest is of great value in helping to insure needed supplies of canned peas. Nicotine dust, commonly used elsewhere, is not effective in Maine because prevailing temperatures in the spring are too low for good volatilization of the nicotine.

Less rotenone for pea weevil.—Effective control of the pea weevil is important in Idaho in meeting the goal of 80 percent increase in acreage of dry edible peas. Cooperative studies of the Idaho station and the Department had already established the value of dusting materials containing rotenone and had proved that a 1-percent rotenone dust was more effective than lower concentrations. In order to conserve rotenone, the War Production Board stipulated that only a 0.5-percent rotenone dust could be prepared and sold. The Idaho station issued suggestions to growers that would help this half-strength material prevent weevil injury. They included the most effective timing of dusting and certain crop measures which would contribute to efficient control. Some combinations of pyrethrum, cryolite, dinitro compounds, arsenicals, magnesium oxide, black pepper, pepperine, and several new synthetic organic materials were included in experimental plot studies in 1942 in attempts to find shubstitutes for rotenone.

Less pyrethrum kills bean beetle.—Concentrated sprays not only save materials but give more effective kills of the bean beetle, according to results of Maryland station research. These sprays are applied with a direct-pressure atomizer utilizing small-aperture nozzles developed by the station and used in experiments for control of this insect. Concentrated sprays containing pyrethrum applied at the rate of 10 gallons per acre gave better results than either regular or concentrated sprays containing rotenone. In one instance, a concentrated spray using but one-half the usual amount of pyrethrum per acre gave good results. Pyrethrum in concentrated sprays appears to be more effective than in normal sprays, since insects seldom recover after being hit.

The sabadilla or green lily, the seeds of which are the source of an insecticide nonpoisonous to man, is under cooperative investigation by the Texas and Wisconsin stations as to possibilities for commercial production in the United States. Plantings of both native and nonnative species have been made at five locations in Texas in order to study the requirements for quantity seed production. Only about 300,000 pounds of sabadilla are imported annually from Central and South America but minimum needs are estimated to be 3,000,000 pounds.

The Wisconsin station discovered several years ago that a kerosene extract of sabadilla was more toxic than pyrethrum. Originally about 70 percent of the samples of sabadilla were nontoxic, but by use of a special treatment developed by the station nontoxic sabadilla can be made effective. Furthermore, by combining sabadilla with a thiocyanate the toxicity may be increased, the resulting mixture being much more effective than either one alone. This combination proved to be 2 or 3 times as effective as grade AA fly spray. Another advantage of sabadilla is the fact that, unlike some insecticidal materials, it seems to have no tendency to lose toxicity in storage. In fact, the toxicity of powdered seed actually tends to increase with aging.

Yam bean.—The yam bean also offers promise of relief from shortage of pyrethrum and rotenone, according to research results obtained

by the New York (Cornell) station. Originally, working with seeds of this plant obtained from China the station found a rotenone-like substance in yam bean seed which proved effective for control of certain insects. Through cooperation with the Department, samples of seed from Central and South America were tested and found to be fully as effective as seed from China. In preliminary field tests during 1943, a 20-percent yam bean dust gave rather uniformly complete control of cabbage worms and Colorado potato beetles, two of the more important early-season pests in western New York.

Cryolite, a fluorine-containing compound first used as an agricultural insecticide about 1932, is now proving a lifesaver for many crops and Victory Gardens. The Tennessee station over a period of years has thoroughly explored the insecticidal value of cryolite and now, chiefly because of its pioneer research, the large-scale substitution of this material for arsenicals, rotenone, and other restricted insecticides in wartime is made possible. In 1943, about 21 million pounds of cryolite will be used in controlling various insect pests. The Alabama station has shown 1 part cryolite and 3 parts talc to be as effective for the Mexican bean beetle as 0.5 percent rotenone.

Tillage and barrier strips save poison baits.—Large savings of arsenicals in poison baits for grasshopper control will doubtless result from tillage experiments by the South Dakota station. In order to create unfavorable egg-laying conditions for grasshoppers in fields this station recommends tillage following harvest but with nontilled strips to be left every 15 to 20 rods in the field to function as egg-concentration areas for the insects which lay eggs only in these strips. Late in the fall, when the grasshopper egg laying has been completed, these strips are likewise tillage-treated to destroy the eggs laid there.

INCREASING SUPPLIES OF ANIMAL PRODUCTS

The production of constantly increasing quantities of meat, milk, and eggs in the United States has been in demand throughout the present war period. Record high levels of production for each of these commodities were established in 1941, while in 1942 the production of meat reached 21.5 billion pounds, milk 120 billion pounds, and eggs 4 billion dozens, which were 10, 3, and 14 percent, respectively, above 1941 levels. National production goals for 1943 called for further increases of 10 percent in the number of hogs, cattle, and poultry for slaughter; 10 percent in eggs; and 2 percent in milk. During the first 6 months of 1943 the volume of meat and meat products was up 17 percent and egg production was 14 percent above levels for the corresponding period of 1942, while milk production was practically the same as for the preceding year.

As labor and machinery supplies become more critical and feed surpluses dwindle, the problems of maintaining record levels of livestock production are becoming increasingly difficult. The question of feed supply is particularly pressing, with grain-consuming animal units on farms at a record level. Obviously, the problem calls for the greatest possible conservation and most efficient use of available feed supplies.

The research findings of the State experiment stations over the years have provided a fund of information that has been of great value in aiding livestock farmers to meet the emergency problems

which are confronting them. Examples of recent experiments directed to the solution of such problems are cited in the following paragraphs.

MAXIMUM USE OF FORAGE CROPS IN LIVESTOCK PRODUCTION

Much has been said and written in recent months regarding the rate of disappearance of feed-grain supplies and the possible need for reduction in livestock numbers with a consequent reduction in the supply of animal products and greater dependence on the cereals and plant proteins in human diets.

While certain adjustments in this direction may become necessary, the fact remains that farm animals, particularly cattle and sheep, normally obtain a high percentage of their total nutrient requirement from pasture, silage, and dried roughages and convert these inedible plant resources into palatable, highly nutritious food products, including meat, milk, and eggs. Ways of utilizing pastures and roughages more extensively in livestock production in order to conserve and extend the use of our limited supplies of feed grains and protein concentrates have been the object of much intensive research during the past year.

Greatest emphasis has been on the improvement and wider use of pasture crops. Permitting animals to obtain the major portion of their feed directly from pasture provides the plant material in its most palatable and nutritious form and eliminates the large amount of labor required to harvest, store, and then feed forage crops to livestock.

IMPROVING AND MAKING BETTER USE OF PASTURES

Pasture management.—The problem of pasture management and rate of stocking is important in connection with more efficient use of pastures. For example, native bluestem pastures have approximately twice the carrying capacity under a system of deferred grazing which permits the grass to attain considerable height before being grazed, as compared with pastures steadily grazed, according to findings of the Kansas station.

Grass pastures allowed to attain heights of 8 and 12 inches before being grazed outyielded grass grazed at the 4-inch stage by 30 and 48 percent, respectively, based on the average of experiments for 3 years at four different locations by the Minnesota station.

Improved pastures consisting of legume-grass combinations, such as alfalfa-brome grass or alfalfa-orchard grass, must be allowed to recover after being closely grazed if the legume is to be maintained in the stand, based on reports of the Indiana station. According to these findings rotational grazing of such pastures would increase their productive capacity by 25 to 50 percent over continuously grazed pastures. This one step in pasture management provides a means for increasing livestock production, especially at a time when the amount of fertilizer available for use on pastures is limited.

A practical pasture-management plan, developed by the Missouri station, which is giving the greatest returns from bluegrass in beef production, provides for heavy grazing until about July 1 and then complete rest of the pasture until the end of the grazing season. Lespedeza and small grains are used for summer and fall pasture

while the dry accumulated growth on the bluegrass fields provides valuable winter grazing.

Pasture development in the Southern States, definitely going forward in pre-war years, has been stimulated greatly by wartime demands for livestock and livestock products.

Good pastures, as determined by the Louisiana station and the Department, can be produced and maintained on Gulf coast soils through the use of basic crops, such as white clover, hop clover, Bermuda grass, and Dallis grass; adequate fertilizer; and good management, including periodic mowing and controlled grazing.

Effective ways to establish and improve permanent pastures in North Carolina have been developed by the North Carolina station. Poor soils should be improved with lime, phosphorus, potassium, and lespedeza before sowing to grasses. Vegetative mulches prevent the drying and crusting of seedbeds on eroded clay soils. Dallis, Bermuda, and orchard grasses, Kentucky bluegrass, lespedeza, and white clover are the best adapted pasture plants. Good permanent sods require control of weeds and brush. Overgrazing may be avoided by the use of supplemental pastures.

Better pastures through improved cultural methods, new plants, and appropriate management, developed by the Florida station, have resulted in rapid expansion of the cattle industry in Florida, with definite increase in dairy and beef products. Productive pasture mixtures and the use of lime and fertilizers, shown experimentally to increase yields, have been quickly adapted to advantage by Florida farmers. Annual lespedezas have proved valuable for pastures on the heavier soils of northwest Florida because of dependability, general adaptation, and high nutritive value. Furthermore, recent research in peninsular Florida has demonstrated that lespedezas may be grown also on low sandy soils.

Growth of pasture plants on many Florida soils has been limited by lack of nutrients needed for normal growth. For example, the Florida station has found that clover on sandy soils may need lime, phosphorus, and potassium, and that grass growth is increased greatly by these elements plus nitrogen. Growth of Dallis, carpet, Bermuda, and Bahia grasses was increased greatly on some soils when certain minor elements were supplied in addition to lime and complete fertilizer. Growth response was best to copper, with manganese, zinc, boron, and magnesium next in importance. California burclover and white Dutch clover did not respond appreciably to minor elements other than boron.

Fertilizers increase quality and yield of pasture.—Numerous studies on the chemical composition and nutritive value of pasture herbage have yielded information of great aid in determining the true feeding value of pastures. For example, in a series of digestion experiments with milking cows, the Virginia station compared freshly cut grass from unfertilized bluegrass pasture with pasture after several years of continuous fertilization with phosphorus and nitrogen plus occasional applications of lime and potash. The herbage from the fertilized pasture had significantly increased in total and digestible protein, in total and digestible fat (ether extract) and in phosphorus, and the ratio of proteins to carbohydrates and of calcium to phosphorus had narrowed as compared with the unfertilized grass.

Thus, actual gains in nutritive value per pound of herbage as well as marked increase in total yield resulted from the pasture fertilization.

Sweet Sudan grass, a select pasture and hay crop released in 1943 by the Texas station, is both sweet and juicy, resistant to several common foliage diseases, and has seed that shatters less than that of common Sudan. A product of several years of crossing, backcrossing, and selection in field and greenhouse, Sweet Sudan, by incorporating desirable characters from Leoti sorgo, lacks some of the shortcomings of Sudan grass. The seed have a reddish brown or sienna glume color that distinguishes them from seed of common Sudan or Johnson grass. The new and old strains are strikingly similar in growth habit and production. The greater palatability of Sweet Sudan was demonstrated in several tests in which cattle grazed the new and juicy strain literally into the ground, while common Sudan grass was grazed down only to a height of 1 foot. Resistance to seed shattering is of economic importance, for the growing of 40,000,000 to 50,000,000 pounds of Sudan grass seed annually is a cash-crop industry on thousands of acres in the Plains region of Texas and New Mexico. An untimely frost or a cool harvesting period with high winds often results in losses of millions of pounds of seed.

Tift Sudan, another good forage grass from hybrids of Sudan grass and sorgo, developed by the Georgia Coastal Plain and Georgia stations in cooperation with the Department, has the vegetative characters of Sudan and the disease resistance of Leoti sorgo. It tends to tiller and to develop more side branches from each stem than common Sudan, and its panicles are smaller, more compact, and yield less seed per acre. Tift Sudan should produce more grazing, especially late in the season, and may be expected to outyield common Sudan when epidemics of foliage disease occur to which Tift Sudan is resistant.

Pasture on weedy hillsides and steep hills.—The Wisconsin station, in cooperation with the Department, has developed a process of converting unproductive hillsides into high-yielding pastures. This system involves an improved method of renovating old pastures by liming, fertilizing, and seeding red clover and sweetclover, and a new type of pasture management under which renovated pastures give higher yields and last longer than ever before. This involves an arrangement of the periods and intensity of grazing to permit the legumes to go to seed and develop young seedlings, holding the bluegrass in check, and obtaining the most grazing possible without injury to the legume seedlings. Advantages of this system include good grazing from May into autumn by alternately using renovated pasture and bluegrass, and by use of steep hills for good erosion-resisting pasture, a nurse crop of oats in the year of renovation, and reduction of weeds and white grubs.

Renovated steep pastures with slopes of 26 to 35 percent have yielded well in comparison with those having more moderate slope, although the latter have produced somewhat better. No erosion occurred on any of these fields or even on an extra steep pasture of 45-percent slope. The Wisconsin station finds that cattle contribute to erosion prevention by tending to graze sparingly on steeper slopes until driven there by hunger. As an example, cattle ate only half of the grass produced on slopes steeper than 39 percent, but consumed 85 percent of the grass

on slopes of less than 20 percent. Wooded hills were found almost worthless for pasture, whereas steep hills with reasonably good cleared land can make valuable contributions to the supply of pasture.

Utilization of forest and wild-land grazing.—Large areas of unused land having potential grazing value offer possibilities for expanding livestock production in some States. In Oregon more than 1 million acres of logged-off land on the coast present a large undeveloped source of beef cattle and sheep production. Experiments on such lands by the Oregon station showed that an average of 80 pounds of beef per acre having a gross value of over $8 could be produced, and gross returns per acre for sheep averaged $9.50 per year.

A study by the Michigan station of the livestock-carrying capacity of different types of wild land and cut-over land in northern Michigan led to the formulation of standards based on ground cover, extent of forestation, available water supply, and other pertinent factors which will serve as a guide in determining whether any given area offers reasonable promise of supporting a livestock venture. Approximately 20 percent of this wild land under public ownership appeared suited to grazing uses.

A survey of forest-grazing practices in the coastal plain section of North Carolina and Georgia by the stations in those States, in cooperation with the Department, showed that forest land contributes a large part of the year-round sustenance of beef cattle in the area, and that still greater expansion is possible since many forest areas containing nutritious native forage have thus far not been used. The development of better practices and proper correlation of the forest-land grazing with that of tame pastures and feed crops, together with improved livestock management, affords a possibility of deriving greater returns from these lands than from growing timber alone.

Range improvement.—Practices developed by stockmen working in cooperation with the experiment stations in Western States and the Department are being applied under practical range conditions and their effects have become evident on the range, the plants, and the livestock. Factors intensively studied have included adapted forage plants, reseeding range and regrassing of abandoned farm lands, weed and shrub control, conservation of soil fertility and water, winter feed production, and grazing and stocking practices.

Returning abandoned cultivated lands to grazing will save short-grass range, according to results of Colorado station and Department cooperative work. In fact, more than 3 million acres in eastern Colorado abandoned in past years are in various stages of natural revegetation, and with proper management may be converted from weedy fields to short-grass range while being grazed. Range improvement, the station finds, is hastened and productivity increased by deferring use until the first stage with its heavy stand of Russian thistle is replaced by a perennial weed cover. The land is stocked conservatively in all recovery stages following Russian thistle and the grazing of weed stages deferred, when possible, until late summer or early fall. Abandoned fields are to be used in conjunction with native grasslands, where feasible, and abandoned lands making a good recovery to native grassland are not to be plowed up.

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Measures to promote reestablishment of grass, developed by the South Dakota station from extensive experiments and being applied by stockmen within the three regrassing areas of South Dakota, involve seeding of introduced and native species of range plants in suitable mixtures and by appropriate practices.

Grading with a road grader, railing, or burning dense sagebrush ranges with an original scattered stand of grass has resulted in substantial increases in grass density and twice as much grass forage in Colorado station experiments. Forage yield three times that of untreated range was obtained by clearing off sagebrush in the fall and reseeding to crested wheatgrass the next spring. Grass revegetation has been hastened by protecting or restricting grazing until after seed maturity the season before and one or more seasons after treatment.

Short-grass range infested with pricklypear, a weed cactus increasingly infesting range areas in the central Great Plains, has also been restored to productiveness by the Department and the Colorado station by removal of the weed by grubbing with shovels or by using a tractor-pulled road grader followed by piling or hauling off detached plants, and proper grazing control and other beneficial practices subsequent to treatment.

Definite possibilities for increasing meat supplies without expanding acreages were found by the Texas station in results of superphosphate applications to range forage on sandy soils of the Rio Grande Plains. In this area of phosphorus-deficient soils, deficiency diseases due to low levels of phosphorus in vegetation have been a serious handicap to cattle production. Superphosphate has increased yields of forage markedly even in dry years and has, moreover, raised the phosphorus content of vegetation above the deficiency level. Through phosphorus applications the carrying capacity was increased from 43 animal units per section on the unfertilized area to 63 on the fertilized area, and average gains increased from 246 to 333 pounds per head.

Pastures for beef cattle.—Cultivated pastures as a supplement to native range have been found by the Washington station to offer an economical way of increasing the production of beef. Combinations such as crested wheatgrass and alfalfa or crested wheatgrass-bromegrass and alfalfa consistently gave live-weight gains of over 200 pounds per acre, whereas yields from pure grass stands seldom exceeded 100 pounds per acre. It was further shown that more beef could be produced in this section by moving weaned calves from range land to cultivated pasture for grazing and finishing. This system of early summer on pasture followed by grain finishing in dry lot brought cattle to market 8 or 10 months sooner than the usual practice of marketing grass-fat steers directly from the range.

At the Oklahoma station wintering calves primarily on silage with a small amount of grain to give about 225 pounds gain during winter, and then grazing for 90 days in early summer on native bluestem pasture followed by full-feeding in dry lot for less than 90 days, has proved to be a sound and profitable practice.

The North Dakota station has shown that calves carried through the winter on a limited amount of feed, mainly hay and silage, which will permit a gain of about one-half pound daily, will make substantially greater gains on summer pasture and more efficient gains in dry lot following pasture than calves which were wintered on more liberal feed to gain about 1 pound daily.

Yearling steers grazed on alfalfa-bluegrass pasture from May 15 to August 28 made gains, which, at prevailing beef prices, were equivalent to a per-acre rate of $24, in an experiment at the Michigan station. These steers, when finished in dry lot, return a significantly higher profit over total feed costs than any comparable group fed in dry lot throughout the summer and fall.

Further work in an experiment at the Missouri station, noted in the annual report for 1942, has shown that satisfactory beef may be produced with a relatively very small amount of corn and other concentrates by carrying good feeder cattle from 24 to 30 months old on roughage alone—including a succession of pasture crops throughout the growing season—and hay and silage in winter; then full-feeding for only a short period. As the age of the cattle increases, the time required in dry lot to produce carcasses that grade Good decreases. Average periods of full-feeding required for satisfactory finish range from 168 days for calves to 35 days for 30-month-old steers. In fact, one group of steers at 30 months of age, which had received no grain, weighed about 1,150 pounds when marketed directly off small grain-lespedeza pasture. The carcasses from this group graded Middle Good. This plan of producing beef assumes great importance in a period of feed shortage such as now exists.

Such a plan of beef production is well adapted to a cropping system developed by the Missouri station, consisting of the growing of an annual crop of small grain followed by lespedeza, which has proved to be a practical and profitable system for that State. The plan is flexible in that it can be varied by harvesting a grain crop, a lespedeza hay or seed crop, or completely pasturing both crops. When both crops are completely grazed, beef yields of 300 to 350 pounds per acre or an equivalent feed return for other classes of animals are regularly obtained. An estimated 42 percent of all Missouri farmers grow lespedeza-grain rotations and nearly all grow lespedeza in some form, a development which is held responsible for the marked gain in the production of animal products from that State in recent years.

In an experiment at the Indiana station, yearling steers wintered on corn silage and clover hay plus about 2 pounds of soybean meal daily, and then full-fed corn on pasture for the final 60 days, consumed about one-third as much corn and about 50 percent more hay and silage than comparable steers full-fed in dry lot for 210 days. The former group averaged about one-fourth pound per day slower gain and were not as highly finished as the full-fed group, but nevertheless yielded satisfactory carcasses at a relatively low requirement in feed grains.

Dealing with the problem of wintering range beef cattle, the Montana station has found crested wheatgrass to be a versatile crop of high value. It previously had proved to be a valuable summer pasture crop, and it has increased greatly in acreage in Montana within recent years. Steers allowed to graze on mature crested wheatgrass pasture and fed 1 pound per day of concentrate were maintained satisfactorily. Steers fed crested wheatgrass hay cut before the bloom stage plus 0.9 pound of soybean meal daily made average gains of 1.3 pounds per day.

Pasture crops for poultry.—The use of pasture crops for chickens as a means of reducing grain consumption is a practical measure long recommended by the experiment stations. Recent experiments at the Michigan station on the actual saving of feeds that may be expected

in growing chickens on various types of pasture indicated that up to 20 percent of the mash, the most expensive portion of the ration, may be saved in this manner, provided scratch grains are available at all times. Frequent clipping to insure an abundance of short, succulent shoots is recommended.

A saving of 25 percent in the requirement of an all-mash ration for laying hens was made when spring growth of bluegrass was available as compared with feeding in a bare lot in an experiment at the Kentucky station. Mature bluegrass was of practically no value in this respect.

Legume and grass pastures were found by the Tennessee station to be helpful in raising chickens and producing eggs. While on suitable pasture the chicks grew faster, utilized feed more efficiently, and more of them lived, than was true of chicks raised on bare ground. Simple diets gave good winter egg production where hens had winter pasture. With wartime shortages of protein feeds especially, such practices can help maintain abundant poultry production on the farm.

NEW DEVELOPMENTS IN PREPARING AND USING SILAGE

The high value of silage in a feeding program for livestock, particularly for dairy cattle, is well established. Now, when the greatest possible conservation of feedstuffs is essential, the ensiling of crops which might otherwise be lost or greatly reduced in feeding value through other types of storage assumes added significance. The use of new or unusual crops for silage or new supplements which enhance the value of silage are of particular interest as a means of increasing the Nation's feed supplies.

New silage crops.—Sweetpotato vines, ensiled either alone or with the addition of 3 percent molasses, produced a silage of good odor and texture which was palatable to dairy cattle, at the North Carolina station. Such silage was high in moisture, containing only about 17 percent dry matter, but in a comparative feeding trial was approximately equal to corn silage in feeding value as measured by milk and butterfat production. Thousands of tons of sweetpotato vines are unused annually, hence this finding represents an important potential feed supply in an area that at present is far from self-sufficient in the production of meat and milk.

Confronted with the problem of meeting livestock-feed requirements with imports from the mainland largely eliminated, the Hawaii station has shown that a number of forage crops and byproducts on the islands may be successfully ensiled, either alone or with the addition of such preservatives as molasses, uramon, and yeast slurry. By these methods good-quality silage has been produced from such crops as Napier grass, koa haole (a native leguminous shrub), pigeonpeas, desmanthus, strip cane (a byproduct of the sugarcane harvest), and pineapple tops and skins, all of which may become important sources of dairy feed.

In view of the current shortage of cane molasses and phosphoric acid, the two most important preservatives in the preparation of grass and legume silage, a significant finding is that of the Florida station that citrus molasses, a byproduct of the citrus canning industry, is quite comparable to cane molasses either for use in dairy feeds or in preserving nonsaccharine forages as silage.

Urea improves food value and palatability of sorghum silage.—More carotene, the precursor of vitamin A, was found in urea-treated sorghum silage (10 pounds per ton) than in silage not treated, and cattle showed a definite preference for the urea-treated material, in experiments conducted by the Mississippi station. The cows fed urea-treated silage maintained their weight through the 78-day wintering tests, while those fed untreated silage lost an average of 47 pounds. After approximately 4 months' storage, the urea-treated silage contained 34.55 micrograms of carotene per gram of dry matter as compared to 22.67 micrograms per gram for the untreated silage. According to this first year's work there probably is a distinct benefit to be had from treating sweet sorghum for silage with a small amount of urea at silo-filling time. Apparently the untreated sweet sorghum does not contain adequate available nitrogen for the proper development of a desirable bacterial flora in the silage material.

Comparative feeding value of silages.—Molasses-alfalfa silage proved somewhat superior to phosphoric acid-alfalfa silage when fed with grain and hay as measured by the retention of nitrogen and phosphorus in milking cows in an experiment at the New Jersey station. Apparently the high phosphorus content of the phosphoric acid silage is unavailable to a considerable extent. It is significant, however, that both of these silages were more economical and supported greater milk production than similar rations with corn silage under New Jersey conditions.

A combination of soybeans and millet provided a silage, which, although somewhat less palatable than corn silage, was approximately equal to it in feeding value when measured in terms of milk and butterfat production, in an experiment at the Maryland station. This crop combination offers possibility of relatively high tonnage per acre in the areas where the production of corn is not feasible.

Utilization of sugar beet tops.—Beet tops, a byproduct in the harvesting of sugar beets, represents a potentially important source of feed in beet-producing States which is by no means fully utilized. For example, the California station estimated that less than 40 percent of the 1942 acreage of beet tops was utilized for feed and that the estimated 3 million pounds of beef produced on this crop could easily have been increased to 12 or 15 million pounds if the tops had been more efficiently conserved. Where large quantities of tops must be handled the preparation of stacked silage is the best method of conservation developed to date, according to the California station. Pasturing tops in the field is the most common method of utilization but is inefficient as generally practiced. Management practices which will permit better returns from pasturing have been developed.

The Colorado station has shown that if only a small quantity of beet tops is to be conserved, and space is available, higher feed value will be obtained by storing the dried tops under shelter. For larger quantities the trench silo is to be recommended. Somewhat higher losses in feed value occurred in stacked silage than in trench silage, as measured by chemical analysis and in lamb-feeding tests. A feeding test with fattening steers showed little difference in the rate of gains or efficiency of utilization of beet tops whether fed as dried tops or as stack silage, indicating that differences in feed cost and handling charges would be the factor determining which method of feeding would be most profitable to the feeder.

PRODUCING AND USING DRIED ROUGHAGE

Hays constitute a very large percentage of the total tonnage of harvested roughage crops and hence occupy a highly important role in livestock feeding. The total production of tame and wild hay in 1942 was estimated to be 105 million tons, of which some 13 million tons were carried over to supplement the 1943 crop. Investigations revealing ways of obtaining the highest possible nutritive value in hay are of obvious significance.

Harvesting hay at the proper stage of maturity is of highest importance as demonstrated in a number of studies.

The quality of the total digestible nutrients in early-cut alfalfa proved far superior to that in late-cut alfalfa in feeding experiments with milking cows at the Michigan station. A ration of the early-cut alfalfa and corn supported as high a level of milk production as one containing the alfalfa, corn, and soybean meal, leading to the conclusion that there is no advantage in supplementing rations of alfalfa hay and cereal grains with protein concentrates when at least 20 pounds of early-cut alfalfa is fed per cow per day. These findings point to the desirability of harvesting alfalfa at an earlier stage than is commonly practiced even though this may mean some sacrifice in total yield.

Similarly, early-cut Korean lespedeza hay was found to contain nearly 40 percent more digestible nutrients than late-cut, highly lignified lespedeza in experiments at the Missouri station. Harvesting of this crop at the optimum stage of maturity generally results in as good yields as later harvesting and is desirable from the standpoint of seed production following the removal of a hay crop.

Soybean hay cut when the beans were three-fourths matured was significantly higher in feeding value for fattening steers than hay cut just after the bloom stage, in a trial at the Kentucky station, indicating that harvesting this crop at an early stage of maturity is undesirable even though early-cut hay may appear superior in texture and color. This finding was confirmed in trials with milking cows at the Missouri station.

By practicing earlier cutting dates for wild-grass meadow hay to yield largest amount of protein per acre, as worked out by the Nevada station, plus seasonal breeding of cattle and sheep, Nevada ranchmen are producing more beef and hides and more wool and mutton from smaller numbers of livestock.

Comparative feeding value of hays.—Feeding experiments made to compare the production value of different types and grades of hay have yielded further information on the returns that may be expected from using them in a farm feeding program.

Alyceclover hay, a comparatively new forage crop well adapted to the Gulf State region of the South, in a feeding trial with milking cows at the Louisiana station proved slightly superior to lespedeza hay in nutritive value. Because of its regional adaptability, rapid growth rate, and comparative ease of harvesting and curing, it is predicted that Alyceclover will play an increasingly important role as a hay crop for the South.

Alfalfa, clover, and soybean hays, supplemented only with ground shelled corn, were compared, in long-time feeding experiments with

dairy cows at the Ohio station. Under these conditions the protein of clover hays proved slightly superior to that of alfalfa hay, although the difference was of doubtful significance. The consumption of total digestible nutrients per 100 pounds of milk produced averaged 101, 103, and 107 pounds for the alfalfa, clover, and soybean rations, respectively, all of which are relatively high, indicating poor utilization of nutrients on these restricted rations. While such simple rations might be utilized during an emergency shortage of protein concentrates and mill feeds, a more varied and complex mixture is recommended.

Further experiments at the Georgia station confirmed an earlier report that peanut hay of good quality ranks high in feeding value for fattening steers when supplemented with corn and cottonseed meal. Other roughages included in the test ranked below peanut hay in the following order: Kudzu, peanuts on vines, soybeans, common lespedeza, and *Lespedeza sericea*.

Marketing alfalfa hay by feeding cattle.—A study by the New Mexico station of the economic aspects of the cattle-feeding enterprise in the Pecos and Mesilla Valleys on irrigated farms producing alfalfa gave evidence that the alfalfa hay could be marketed to better advantage by fattening either stocker-feeder calves or yearling steers for slaughter rather than by shipping the alfalfa to outside markets. The feeding of cattle also provided a means of converting considerable quantities of waste farm pastures and feeds of low quality into beef at a good profit.

Alfalfa meal in turkey rations.—Alfalfa meal up to 25 percent of the total ration can be used to advantage in the economical feeding of turkeys from 7 weeks of age until ready for market, according to findings of the Utah station. Since alfalfa meal of excellent quality is available in that area for about one-half the price of small grains, this offers a good opportunity for utilizing larger quantities of a local product at a profit and conserving the scarce feed grains.

Mechanical advances in making hay and silage.—Considering the relatively high labor requirements for harvesting and storing hay or silage, any developments which reduce the amount of labor required are of obvious importance.

A field forage harvester developed by the Wisconsin station has an attachment that cuts standing corn, and chops and loads it in one operation; a mower-cutterbar that mows hay crops, chops the material, and loads it; and a pick-up attachment that chops and loads windrowed dry hay or straw left by combines. A new crop blower sends an even flow of silage up the blower pipe. A corn meal attachment for silage cutters and blowers applies an even and easily regulated stream of meal to the forage as it passes over the feed table. Use of the equipment for forage harvest reduces the amount of labor required and cuts the cost of silage making in half. The equipment was tested on several farms during the first-crop haymaking period, cutting up 975 tons of silage in 16 silos on private and station farms. The feasibility of putting up silage on a custom basis was demonstrated by the successful use of the equipment.

Saving labor in haymaking.—The large labor requirement in haymaking at a time when labor is needed for harvesting more perishable crops contributes to low total yields and a hay of poor quality.

Efforts of many of the stations have been directed toward developing equipment to reduce the labor requirement and thereby encourage haymaking at the proper time for the highest nutritive value. Plans for an autotruck buck rake, an overshot stacker made entirely of poles, and a slide hay stacker developed by the Oregon station are typical examples of the labor-saving equipment recommended.

Similarly, the Idaho station has provided information on how to build and operate a tractor pusher, auto buck rakes, hay stackers made of salvage materials, and equipment for straightening old bailing wire.

An improved home-made auto buck rake, developed by the Montana station, incorporates greater hay-load handling capacity and greater flexibility, which saves time and travel distance and permits handling of heavy loads of baled hay over rough ground and irrigation ditches.

Pick-up for baled hay.—Further aid in the mechanization of hay harvesting designed especially to relieve labor shortage and to permit substitution of women for men in the heavy work of picking up baled hay in the field has been developed by the California station. The machine runs on 2 wheels and 2 runners and is attached to the side of the truck on which the bales are to be loaded. The power required to lift the bales is taken from the ground through the 2 wheels of the loader, thence through 2 automobile rear axles to sprockets and chains in the bale chute up which the bale is drawn to the delivery platform 2 or 3 feet above the truck bed. Loading rates of 5 to 6 bales per minute were obtained in field tests of this equipment.

Barn-loft curing of hay with forced ventilation through properly arranged ducts and vents, developed originally by the Tennessee station in cooperation with the Tennessee Valley Authority, has continued to win recognition. Experiments with this type of barn-loft installation at the Illinois station gave further evidence that legume hays could be loft-cured satisfactorily under weather conditions in which field-cured hay was completely lost. The Ohio station likewise obtained a good-quality hay and found danger of fire from spontaneous combustion removed by this method of barn drying.

PRODUCING AND CONSERVING FEED GRAINS

The importance of increased production and conservation of feed grains becomes apparent in view of the fact that our total supply reached an all-time high of 155 million tons in 1942, yet only 11.5 percent was carried over to 1943. The number of grain-consuming animal units in 1943 is estimated to be more than 10 percent above the number in 1942, hence even with a total supply of feed grains as large as in 1942 the supply per animal unit will be less in 1943. Recognition of this critical situation by the State stations has resulted in a number of emergency studies dealing with the problem of conserving and extending available feed supplies, supplementing continuing studies of production and use of feed grains.

Hybrid seed corn has been a most important factor in reaching the national corn goals set for 1942 and 1943. The rapidity and extent of the hybrid-corn movement in the United States, largely an outcome of investigations by the stations and the Department and

one of the greatest forward steps in the history of agriculture, are revealed in departmental surveys which show an increase from 143,000 acres of hybrid corn, or 0.1 percent of total corn acreage, in 1933, to 49,964,000, or 51.6 percent, in 1943. The greater resistance to lodging and the gain in yield over open-pollinated corn under like conditions, estimated at about 20 percent, are reasons for the increase in popularity of hybrid corn. The use of hybrid seed is centered in Iowa, where it was planted on 98 to 100 percent of the corn acreage in every county. The percentages of the 1943 corn acreage planted in hybrids were, in Iowa 99, Illinois 96, Indiana 96, Ohio 92, Minnesota 88, Wisconsin 81, Missouri 71, Nebraska 63, and South Dakota 44. The concentrations in these Corn Belt States were surrounded by belts which showed intensification and expansion of use of hybrid seed, and there were important scattered areas throughout the North and irrigated West.

Adapted hybrids for the Southern States, where corn is not a primary cash crop, has been a more gradual development, but with rapid recent gains. Hybrids developed by the Louisiana station and the Department, for example, have outyielded the regular varieties by 20 to 25 percent and even up to 50 percent, and as a result production of hybrid seed has been stepped up to meet a rising demand. The popularity of these hybrids is based on the two or more ears per plant, the sturdy wind- and drought-resistant plants, insect and disease resistance, and the close-fitting husks, affording special barriers to entrance of weevils in the field and in storage. The superiority of certain Louisiana hybrids (3802 and 468) was also demonstrated in Mississippi station experiments where Louisiana 3802 yielded 17 percent more than the check average for all locations and 11 percent above Mosby, the best open-pollinated variety.

Expansion of hybrid-corn acreage in New Jersey.—Records of the New Jersey station since 1935, when the first New Jersey hybrids were offered, show that the station's hybrids average 10 to 20 bushels more per acre than open-pollinated types. New Jersey farmers planted only 5 percent of their acreage in hybrids in 1939; by 1940 the percentage had jumped to 20, and preliminary reports for 1943 indicate that 71 percent of the 187,000 acres of corn was planted to hybrids.

Hybrid seed corn production in Texas has expanded rapidly in response to emergency needs. In 1943 nearly 150,000 acres were planted to hybrid varieties developed by the Texas station as compared to about 60,000 acres in 1942. In addition, some 2,500 acres were devoted to the production of hybrid seed corn for use in 1944. For the past several years, the acreage of hybrid corn in the State has doubled annually. The best station hybrids in 1942 tests yielded about 20 percent more than standard open-pollinated varieties despite greater susceptibility of the hybrids to earworm and weevil damage.

Hybrid corn is also proving its value in Florida. Florida W–1, the hybrid corn grown on 160 acres by commercial growers from seed developed and released by the Florida station, yielded about 3,000 bushels of salable seed in 1942. Use of this productive seed was expected to considerably increase the total yield of corn in Florida in 1943. Concurrent with the corn breeding is seed-storage research. High temperatures have been held responsible for rapid deterioration of seed corn in Florida. The station observed that cold treatments of

seed corn even for short periods increased its longevity when exposed afterwards to higher temperatures.

New field corn hybrids, Maine A and Maine B, crosses between chosen selections of flint and dent corn first developed by the Wisconsin station, have been released by the Maine station to help farmers of the State in their all-out effort at feed production for 1942. They have proved superior in yield of both grain and roughage to common varieties of flint corn in comparative trials in central and southern Maine.

Corn fed as mature-corn silage in Ohio station experiments gave approximately 50-percent greater return in terms of beef per acre than corn husked in the field and fed as corn-and-cob meal, while immature corn silage gave intermediate results. In order to obtain the maximum feeding value per acre of corn the station recommends that the corn be ensiled after the kernels are well dented but while most of the leaves are still green or at a stage just shortly before it could safely be cut and shocked.

Another significant finding of the Ohio station is that when corn-and-cob meal was fed in a practical steer-fattening ration the cobs possessed a feeding value equal to alfalfa hay. Thus, it is evident that a great waste of nutrients occurs when corncobs are discarded.

Limiting the period of full-grain feeding has been found by the Indiana station to be a practical way of conserving grain in fattening steers. Steers on full feed of corn for only 90 days, following 4 months on silage, hay, and soybean meal, consumed only 44 percent as much corn, 36 percent more silage, 50 percent more hay, and the same amount of soybean meal as steers on full feed for 210 days. While the former group weighed 34 pounds per head less at the end of the trial and graded somewhat lower than the full-fed group, they returned practically as large a profit over feed costs and yielded satisfactory carcasses at a marked saving in the amount of corn fed.

Utilization of immature corn.—Immature soft corn damaged by mold and rot had a relatively high feeding value in experiments at the South Dakota station. Cattle fed the soft corn actually made faster and cheaper gains than those fed good No. 3 ear corn. Pigs also made good gains on the soft corn, with as low feed requirements as those fed hard ear corn. Lambs fed the soft corn and hay made satisfactory gains but required more feed per 100 pounds of gain than those on hard corn. Thus, it is evident that late corn which fails to mature before frost still has a relatively high feed-lot value.

Corn affected by dry rot (diplodia) so that the grain was unfit for many uses was fed to pigs without deleterious effects in trials at the Iowa station. Although the rate of gain was somewhat below that of hogs fed sound corn, it does offer a way of utilizing such mold-damaged corn.

Cattle feeding tests by the Colorado station completed in June 1943 showed the feasibility of fattening on feeds not affected by war-time shortages. Steers were fattened without protein supplements when high-quality alfalfa hay was used as the roughage portion of the ration. These tests also showed the feasibility of cutting down the amount of grain used in the fattening ration. Steers fed alfalfa hay, sugar beet tops, wet sugar beet pulp, and a low level of grain made the most economical gains in the test. Packing-house studies of the

carcasses showed the meat produced on low grain-beet byproduct rations to be as high in finish and quality as any meat except that produced on a high-cost, high-concentrate ration.

Grain sorghums as substitutes for corn.—Although corn has been the backbone of the cattle-feeding industry, grain sorghums are making headway in the more arid sections of the Great Plains.

Comparison by the Kansas station showed that 2 new combine-type grain sorghums, Colby milo and Wheatland milo, were equal to shelled corn when ground medium fine and fed with Atlas silage and cottonseed meal to calves to provide protein. These results are of great practical value in areas where sorghums are being grown. Milo-fed pigs also made excellent gains, several lots excelling the gains made on shelled corn.

In a series of experiments by the Texas station, in cooperation with the Department, steer calves full-fed milo grain with cottonseed meal and sumac fodder or silage made the very satisfactory average daily gain per head of 2.16 pounds with a calculated efficiency of 16.76 pounds of gain per 100 pounds of digestible nutrients consumed. Similar steers limited to 80 percent of full sorghum-grain consumption gained 1.94 pounds daily on the average but at the more efficient level of 17.41 pounds of gain per 100 pounds of nutrients consumed and at a considerable saving in the total amount of grain required.

Double dwarf milo and black-eyed cowpeas were hogged down in an experiment conducted at the California station during the summer and fall of 1942. The crops were planted in May and the hogs put in during September when they weighed about 95 pounds. In one lot cowpeas and milo were planted in the same row; in another they were planted in separate rows; and there were two lots in which no cowpeas were planted. During a 3-week period in which the pigs were harvesting these crops those on milo alone made less than 1 pound of gain per head daily. In those lots where both milo and cowpeas were included the average daily gain was 1.5 pounds per head daily. A satisfactory hog-fattening ration, involving no labor for harvesting or feeding, was thus provided.

Limited grain feeding for dairy cows.—Numerous references to experiments dealing with the problem of roughage alone versus roughage and grain for milking cows appear in earlier annual reports. In general, good roughage alone has been found to support 65 to 75 percent as high a level of milk production as can be obtained with roughage plus liberal feeding of mixed grain.

In a series of carefully controlled experiments at the Iowa station an all-roughage ration of alfalfa hay and corn silage supported 75 to 81 percent as high levels of milk production as a ration consisting of the roughage plus 1 pound of grain to 3.5 pounds of milk. Actually the nutrients in the all-roughage ration were utilized more efficiently, 5.76 pounds of milk being produced for each pound of total digestible nutrient consumed above the maintenance requirement as compared with 3.2 pounds of milk per pound of TDN on the roughage and liberal grain ration. Part of the production on the roughage ration was at a sacrifice in body weight, since in all cases cows tended to lose weight on this ration. A ration of roughage plus 1 pound of grain per 7 pounds of milk gave intermediate results. The ratio of feed prices to that of milk or butterfat should determine the most profitable rate of grain feeding.

More lambs on a balanced feed.—The Kansas station, as a result of a series of carefully conducted experiments, determined that with corn and cottonseed meal or soybean meal as the concentrate, best gains were made with the greatest economy with 45 percent of the feed as concentrate and the rest roughage. As a rule, decreasing the proportion of concentrate to 35 percent or increasing it to 55 percent resulted in lower growth rates. This happened whether alfalfa silage, sumac-sorghum stover, alfalfa, or wheat hay was used as silage and regardless of the concentrates used, whether corn and cottonseed meal, corn and soybean meal, milo grain and cottonseed meal, corn alone, or kafir, barley, and cottonseed meal. This information will be of direct and widespread value to lamb feeders in attempting to make the greatest possible contribution in the meat-production program.

Testing various combinations of feed, self-fed to lambs in order to eliminate the labor of hand feeding, the Minnesota station found a mixture of 60 parts cracked corn and 40 parts cut alfalfa, self-fed with or without additional whole alfalfa, to be highly satisfactory from every standpoint. Where grinding grain or hay was not practiced a self-fed mixture of 3 parts corn and 1 part oats plus whole alfalfa proved to be a satisfactory ration, giving gains only slightly less efficient than a hand-fed ration of shelled corn and alfalfa.

A report from the Indiana station covering a series of experiments on the value of various rations for fattening western lambs, indicates that the feeding of a small amount of clover hay daily significantly enhanced the value of a ration of corn silage, shelled corn, and cottonseed meal. With the clover hay present the feeding of calcium and phosphorus supplements was of little value, whereas in the absence of the hay such supplements were of distinct benefit. From the standpoint of increasing gains or market finish of the lambs there was no advantage in chopping legume hays or cracking the corn.

In a similar study the Illinois station found no advantage from additions of a mineral mixture or cobalt supplements to a ration of alfalfa hay, corn silage, shelled corn, and soybean meal. Also, no definite advantage was shown in the feeding of western lambs shorn before feeding as compared with the feeding of unshorn lambs.

Feeding sugar beet molasses to hogs.—Hog-feeding studies by the Utah station have shown that young hogs may be safely fed sugar beet molasses up to 40 percent of the ration, provided they receive the equivalent of 5 percent of hay as fresh-cut green alfalfa or 5 percent of dried brewer's yeast. Sugar beet molasses is a byproduct of beet-sugar manufacture and is a comparatively cheap feed, plentiful in the State.

Sun-dried cull potatoes as pig feed.—In the lower San Joaquin Valley of California cull potatoes are sun-dried and then ground to make a product sold as potato meal. When fed with barley and properly supplemented with protein concentrates, alfalfa meal, salt, and lime, the California station found that this product could be utilized without cooking and that it had a value similar to that of barley. Larger and older hogs (100 pounds) did better when fed 40 percent of this product than did younger hogs (50 pounds). When the product was fed at 10- and 20-percent levels there was not much difference in the efficiency of the pigs of varying ages and weights.

Dried sweetpotatoes as feed for livestock.—The Texas station in its sweetpotato laboratory at Gilmer has developed a potato slicer and a method of sun-drying sweetpotatoes and of storing and using this sun-dried product for feeding livestock in east Texas. This is an important contribution in a territory where sweetpotatoes are much more productive than are corn and other carbohydrate feeds. Large numbers of cull potatoes can be used in this way. The sweetpotato has more than 80 percent of the feeding value of corn and is an admirable source of carotene, a precursor of vitamin A.

Sweetpotato meal made from culls was found by the Hawaii station to be valuable as a substitute for imported concentrates. Using 11.5 percent of this meal with 1.5 percent soybean meal in place of 13 percent corn meal did not significantly reduce milk production in a 9-week double-reversible trial. When cut with a shredding machine adapted from a design worked out at the Alabama station, the material was dried successfully on an outdoor concrete floor in 48 hours even when a shower intervened. The cost was estimated at less than $3 per ton of dry material, while sweetpotatoes shredded and dried by the process used for pineapple bran cost from $15 to $20 per ton.

Sweetpotato meal was used successfully to replace up to 25 percent of the usual source of carbohydrates in chick rations in trials at the Louisiana station. Rations containing 30 and 40 percent of sweetpotato meal were not as satisfactory as an all-grain ration or the rations containing lower levels of potato meal. Rations containing two cereal feeds in addition to sweetpotato meal were as good as, and in some combinations significantly better than, an ordinary chick ration. Sweetpotato meal was palatable to chicks and had no undesirable physiological effects. The storage and keeping qualities of sweetpotato meal were equal to or better than those of the other carbohydrate feeds used.

Fat required in poultry rations.—Previous reports have cited the satisfactory results of feeding experiments in which the fat content of poultry rations has been considerably lowered without any apparent ill effect on laying hens. Because of wartime scarcity of fats, the work of the New Jersey station was extended to include still greater reductions in fat content. In a new series of feeding trials one group of hens received a normal ration containing 3.2 percent fat, another group a ration with 2.4 percent, and a third a ration with 1.6 percent fat. No significant differences were observed in the behavior of the birds in the three pens. The data continue to indicate that a reduction of approximately one-half in the fat content of a poultry ration has no effect, either beneficial or detrimental, on laying hens.

Feeding cane molasses as a constituent of poultry rations.—In trials at the Pennsylvania station the inclusion of 2 to 6 percent of cane molasses in the ration of young chicks resulted in higher feed consumption per bird but lower efficiency of feed utilization than when no molasses was fed. Similar additions of molasses to the ration of adult birds had no significant effect on performance as measured by body weights, egg production, and hatchability. In this case it appeared that the relative cost of yellow corn and feeding-grade molasses should be the determining factor in the use of these feeds.

Degreased garbage for poultry.—Kitchen waste from Army camps is a large local source from which, by processes tried out at the Hawaii experiment station, relatively inexpensive supplies of protein for feeding and fat for glycerine are obtainable. For poults the degreased garbage was found satisfactory as a substitute for 40 percent of a commercial feeding mash. A chemical solvent was used to extract the fat from garbage, leaving a friable product of excellent keeping quality readily eaten by poultry. The extracted fat amounts to one-fourth of the weight of the dry garbage and has a local market value.

Storing feed grains.—Solution of grain-storage problems was aided by the Illinois station through the development, testing, and perfection of a prefabricated, plywood, demountable, 1,600-bushel grain bin. Plans were widely distributed and many bins of this type were erected in the fall of 1942. The station conducted experiments to provide information on the treatment, including turning, cleaning, and insect fumigation, needed to insure retention of quality in soybeans containing 15 percent or more of moisture.

The needs of poultrymen and others for a quickly assembled bulk grain bin of reasonable cost was met by the California station by the development of a plywood grain bin having a capacity of 12.6 tons of wheat.

Storage of grain sorghum without deterioration is an important aspect of the meat-production program in the more arid sections of the southern Great Plains. Investigating this problem, the Kansas station found that grain sorghum cannot be stored safely in underground pits where the soil is moist. The grain may be kept for as long as a year without deterioration in ordinary unventilated bins if the original moisture content is not above 12.5 percent. Where the grain is of higher moisture content power ventilation should be used to reduce the moisture to 12.5 percent so as to prevent spoilage.

MAKING PROTEIN SUPPLIES GO FARTHER

While the production of high-protein feeds in the United States has increased sharply during the last 2 years, it has not kept pace with the more rapid increase in livestock population. Furthermore, the increase has occurred wholly in the field of oil cakes and meals since the total tonnage of animal proteins, particularly fish meal, has declined during that period. This situation has necessitated not only a reduction in the per-animal consumption of protein concentrates but also in a shift from animal to plant sources, particularly for swine and poultry, the chief consumers of animal proteins.

These adjustments have created many nutrition problems for solution by the experiment stations.

Minimum protein requirements.—In a study of the lowest practical level of protein feeding for dairy cows, the Puerto Rico University station found under tropical conditions that a 16-percent protein level in the grain ration was as effective as 20 percent for milk production and that a ratio of 1 pound of concentrate to 3 pounds of milk produced was as adequate as a 1:2 ratio. These results are enabling dairymen to economize materially in the amount of protein fed per cow in an area where protein-rich feeds are extremely scarce.

Helpful in the current shortage of protein feeds are the results of an experiment conducted by the California station to find out if pigs could

grow and fatten on less protein than is generally recommended. Pigs weighing from 50 to 100 pounds that were fed 10 percent tankage, with other feeds, then 6.5 percent tankage at from 100 to 150 pounds and 3 percent at from 150 to 225 pounds, gained just as rapidly and produced their gains on the same amount of feed as those fed 10 percent tankage from 50 to 225 pounds weight.

The Hawaii station has shown, however, that high-protein rations for sows are essential if the young pigs are to be vigorous at weaning time and if the sow herself is not to lose weight excessively. This presents a serious problem in the territory as protein supplements have to be imported and are the most difficult types of feed to obtain.

Under emergency conditions, when protein for chick feeding must be conserved, the New Jersey station has found that the quantity may be reduced to as low as 17 percent in chick-starting rations without causing any serious injury to the mature pullet. Slightly higher percentages for the first 6 weeks are advisable. After the age of 12 weeks all protein concentrates may be omitted from the diet of growing pullets provided they have access to range.

Increasing the protein content of the mash ration of growing turkeys from 22 to 40 percent did not increase the rate or efficiency of gain but did significantly increase the cost, according to a recent report of the Missouri station, leading to the conclusion that the use of concentrates containing high percentages of proteins is not to be recommended for turkeys. This finding confirms reports by the Oklahoma and Indiana stations.

The efficiency of various protein combinations.—Many recent experiments have dealt with new sources and combinations of protein concentrates to replace those commonly used in the past.

Experiments reported by the New York (Cornell) station, covering a total of 86 lactations, indicate clearly that the kind or quality of protein fed is of little practical importance in any ordinary grain mixture for dairy cows, even when but little of the roughage consists of legume forage. This means that, in making up a grain mixture for dairy cows, one can use whatever protein supplements are available so long as the mixture is palatable to the cows and made up of satisfactory feeds for milk production.

Similarly, the South Carolina station found no major differences in the effects of cottonseed meal and peanut meal upon milk properties when either constituted up to 50 percent of the concentrate mixture. A milk producer evidently may safely interchange these meals in the dairy ration without seriously changing milk properties.

Steers fattened on rations of ear corn in the husk and peanut straw, with velvetbeans as the protein supplement, made average daily gains of 2.11 pounds and required less corn and peanut straw per unit of gain than other similar groups with cottonseed meal or peanut meal in place of the velvetbeans in experiments by the Georgia Coastal Plain station cooperating with the Department.

Fattening steers receiving corn and alfalfa hay responded favorably to protein supplements in trials at the Nebraska station. With 2-year-olds, yearlings, and steer calves, 1 ton of cottonseed meal saved approximately 37.3, 46.77, and 22.64 bushels of corn, and 1.33, 0.4, and 0.028 tons of alfalfa hay, respectively. When corn silage was included in the ration for yearling steers, 1 ton of linseed meal replaced 2.78 tons

of corn silage, 0.22 ton of alfalfa hay, and 51.5 bushels of corn. Somewhat greater gains were made with groups of steer calves fed cottonseed cake than with those fed tankage or soybean cubes, but there was little difference in the economy of the gains of those receiving the last two protein supplements.

Soybean meal for swine and poultry.—Numerous studies have been conducted on ways of using soybean meal to the best advantage for swine and poultry feeding, since the supply of this product has increased much more than any other protein concentrate. In the feeding of swine and poultry, it has been found best to use meals that have been given the proper heat treatment to insure best results.

In comparing various protein feeds as supplements to a ration of corn, wheat shorts, rice bran, and alfalfa meal for fattening hogs, the Louisiana station found that soybean meal produced the most economical gains and the second best rate of gain, being exceeded only by a mixture of soybean meal and shrimp meal. Ranking below these supplements in economy of gain were shrimp meal alone, shrimp meal and cottonseed meal, and cottonseed meal alone.

The Minnesota station reports that the amount of animal protein for growing fattening pigs can be reduced by one-half without detrimental effect if it is replaced by soybean meal.

For fattening pigs in dry lots on corn, protein supplement, and mineral mixture, the Ohio station found that soybean meal was worth 83 percent as much as tankage, pound for pound, and resulted in more economical, although slightly slower, gains. Very similar results were obtained by substituting linseed meal for tankage. For fattening pigs on pasture with corn, a supplement of either soybean meal or a 1:1 mixture of soybean meal and cottonseed meal supported more rapid and more economical gains than tankage.

From the numerous experiments on the maximum extent to which soybean meal may replace animal proteins for poultry it may be concluded that, when adequately supplemented with minerals and vitamins, particularly some rich source of riboflavin, animal protein may be entirely eliminated from the rations of either growing chicks or laying hens with reasonably good results, and optimum results can be obtained when only a small percentage of animal protein is used to supplement the soybean-meal proteins. For example, in trials at the Washington station, soybean meal, when used as a sole source of supplemental protein for growing chicks at a level of 20 percent protein, gave satisfactory results when the diet was properly fortified with vitamins and minerals. Hens fed a diet containing no protein supplements except soybean meal and corn-gluten meal maintained good egg production during a 9-month experiment at the Maryland station.

The New York (Cornell) station found that as little as 3 percent fish meal promoted maximum growth in White Leghorn cockerels when the balance of the protein was obtained from 25.5 percent soybean meal. Although pullets laid normally and the eggs hatched well when soybean meal was given as the sole protein supplement, a loss in weight of the pullets occurred in a 30-week experiment. This loss was prevented when about 2 percent meat scrap was added to the ration.

During a 6-month experiment by the Delaware station a complete poultry diet containing only 1.25 percent animal protein was found to compare favorably with one containing 6.75 percent animal protein when total protein, calcium, phosphorus, and vitamins A, B_2, and D were kept at the same level. These results indicate that it is possible to build up good rations containing small amounts of animal protein.

Recent Kentucky station tests gave encouraging results when soybean meal plus steamed bonemeal was fed instead of meat scrap to poultry allowed to range on bluegrass.

Other experiments at the California, Colorado, Connecticut (Storrs), Illinois, Indiana, Iowa, Kansas, Mississippi, Missouri, New Hampshire, Ohio, and Wisconsin stations tend to confirm these findings.

In studies of specific nutritive deficiencies of soybean products, the California station found that raw soybean protein was strikingly deficient in the amino acid methionine, and that heat-treated soybean protein was likewise deficient but to a lesser degree. The Indiana station has concluded that the principal deficiency of soybean meal in chicken rations, as compared with common animal-protein concentrates, is available choline. When this deficiency is met soybean meal can be successfully used as the sole protein cencentrate.

Improving the quality of cottonseed meal.—The extensive use of cottonseed meal for hog and poultry feeding has been limited by its toxic properties plus the fact that the yolk of eggs from hens fed cottonseed meal has tended to develop off-color during cold storage, both due to free gossypol in the meal. The Texas and Alabama stations have developed principles applicable to the commercial production of cottonseed meal whereby it can be produced free from all toxic properties. The free gossypol content of the meal was found to be dependent on the moisture and heat treatments to which the meal was exposed during manufacture. General application of these findings would greatly expand the potential use of this important protein concentrate.

New sources of proteins.—The utilization of every available source of feed protein becomes desirable under the stress of shortage. Experiments with milking cows and fattening lambs at the Missouri station gave evidence that ground lespedeza seed is practically equal to cottonseed meal or soybean meal as a protein supplement, while with poultry the whole lespedeza seed was successfully used.

Dried brewer's yeast added to the turkey-growing ration in Kansas station experiments increased the ration cost, but the toms ate so much more feed and gained so fast that the average profit was higher for the turkeys fed the yeast. It did not affect the growth rate of the hen turkeys.

The California station has found that some fractions of beef-blood proteins, such as fibrin and serum, are of good quality while the blood-cell proteins are very poor in quality. Research is now aimed at locating the defects of the blood-cell proteins in order that they may possibly be corrected. If successful, this would make available a considerable tonnage of protein for feeding chickens.

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No evidence of toxicity was noted from solvent-extracted tung oil meal fed as 4.9, 9.6, 14.1, and 18.5 percent of a cereal ration with alfalfa-leaf meal and meat scrap to 12-day-old chicks for 5 weeks in trials at the Florida station. The meal was unpalatable, however, resulting in reduced feed consumption and gains. It appears that this product may be used as an emergency feed but only to a limited extent.

Dogfish meal, prepared by dry-rendering methods commercially and experimentally, was found by the Washington station to have little value as a protein feed. On the other hand, samples of the meal prepared experimentally by wet process had relatively high apparent gross protein values, comparable to those obtained with Pilchard fish meal and soybean meal.

Powdered swine hoofs were a satisfactory substitute for meat scrap and fish meal in practical rations for day-old chicks, in trials at the Wisconsin station. The keratin proteins in this material appeared to be of particular value for animals producing quantities of keratin tissues, such as feathers.

Koa haole, a tropical leguminous shrub, can be grown abundantly in Hawaii. As demonstrated by the Hawaii station the shoots can be cut as a continuing source of highly nutritious green feed for cattle. In tests in which 17 ratoon crops have been harvested in 4 years from a single field there was no diminished vigor in the plants. When grazed on koa haole, 16 dairy cows maintained their milk production during a 4-week test which resulted in a saving of 1,870 pounds of soybean meal, or a total saving in cost of concentrate feeds of about 13 cents a day per cow.

Urea as a protein substitute in wartime.—Experiments by the Wisconsin and Hawaii stations with growing cattle and milking cows, and by the Illinois and New York (Cornell) stations with lambs, have yielded conclusive evidence that these ruminants can utilize nonprotein nitrogen in the form of urea to meet a high percentage of their total protein requirements.

From Wisconsin station findings it is calculated that urea (42-percent grade) is worth $113 per ton in dairy rations, when linseed meal is worth $45 per ton, corn or oats $35, timothy hay $15, and corn silage $5 per ton. The inclusion of 3.5 pounds of urea per 100 pounds of grain mixture will provide a suitable nitrogen level for feeding with home-grown hay and silage. Each ton of urea will supply an amount of nitrogen equivalent to 7 or 8 tons of the usual protein concentrate. These findings offer one way of alleviating an acute protein-feed scarcity.

MEETING VITAMIN AND MINERAL REQUIREMENTS OF FARM ANIMALS

Recognizing the many minor nutritive factors required by animals and supplying them in adequate amounts is especially important at this time when maximum efficiency of feed utilization must be attained.

PROVIDING NEEDED VITAMINS

The constant research for new, unidentified vitamins which may be essential has gone on while new sources of the commonly recognized vitamins have been sought for use in correcting deficiencies arising out of the emergency-feeding program.

Vitamin A for cattle.—In a study of the adequacy of fall and winter range grasses for meeting the carotene or provitamin A requirements of cattle, the Texas station found a marked variation in the carotene of different grasses in the dried or dormant stage, ranging from 2 parts per million in Bermuda grass to 94 parts per million in buffalo grass. It was concluded that practically all of the dried or dormant range grasses would supply enough carotene for the maintenance requirement of beef cattle but not enough for high-producing dairy cows.

The influence of increasing the vitamin A content of good practical dairy rations by the addition of shark-liver oil has been investigated by the Florida and Wisconsin stations. They agree in showing that milk and butterfat production are not significantly affected by such supplements. The Wisconsin station found a rather marked increase in the vitamin A content of milk as a result of adding shark-liver oil, but according to the Florida station the increase in vitamin A cannot be expected to exceed a threshold value of about 1,900 International Units per quart, a level that can be obtained on a good ration of natural feeds.

Vitamin requirements and sources for swine.—In an attempt to determine whether there is a relation between nutrition of the sow and the growth and mortality of young pigs, one group of sows and boars at the New Jersey station was fed a practical hog ration while another was given a semisynthetic ration deficient in certain of the B vitamins. Animals on the practical ration mated and produced young normally; those on the highly purified ration did not. When the ration was deficient in pantothenic acid the pigs showed characteristic "goose stepping." Animals fed rations deficient in vitamin B_6 (pyridoxine) showed a characteristic anemic condition. The evidence indicates that the nutrition of the sow during pregnancy and nursing has a most important bearing on young-pig mortality.

Fits were produced in pigs when kept on floors free of molds and yeasts and supplied with diets deficient in vitamin B_6, in experiments at the California station. When these pigs were given 5 milligrams of synthetic pyridoxine per 100 pounds live weight they made normal gains and returned to normal blood hemoglobin and normal healthy condition. The requirement of young pigs for pyridoxine hydrochloride was thus established as between 0 and 5 milligrams per 100 pounds live weight.

High mortality in suckling pigs has been established as primarily due to nutritional deficiencies by the Missouri station. A synthetic ration containing all known vitamins proved inadequate for pigs between the ages of 2 and 56 days. Yeast proved to be a fairly good source of the unrecognized vitamins, suggesting that more complete recovery and use of brewer's yeast as a supplement to pigs' rations is to be recommended.

The Michigan station confirmed a previous finding that nicotinic acid deficiency is a predisposing factor in swine enteritis, and found in addition that at least one other unrecognized member of the vitamin B complex supplied in fresh liver but not in dried yeast is highly essential in preventing this disorder.

Ohio station experiments show that irradiated dried yeast can serve as an inexpensive and effective source of vitamin D for swine. At

present prices vitamin D in the form of irradiated dried yeast costs from one-eighth to one-tenth as much as vitamin D in the form of fish oils or D-activated animal sterols.

Vitamin A for poultry.—A study of the utilization by laying hens of carotene from various sources (crystalline carotene, carrots, and alfalfa) compared with vitamin A from shark-liver concentrate by the California station showed that vegetable sources of carotene are efficiently converted into vitamin A by hens. The level of A-potency in the egg is affected by the level of vitamin or provitamin in the diet but not by the source of the vitamin itself. This point is of particular importance to the poultry industry in view of the shortage of fish-liver oils.

From experiments to determine the feasibility of using dehydrated alfalfa as a source of vitamin A, the Idaho station found that good-quality dehydrated hay in the starter ration serves as a good source of carotene and riboflavin for young chicks, and that it can replace vitamin A obtained from fish oils.

At the end of 14 weeks' feeding experiments at the Delaware station there was little difference in the growth induced in broilers of both sexes on all-mash rations in which western sun-cured alfalfa was compared with dehydrated locally grown clovers and perennial grasses. Feed utilization, livability, and feathering were similar and satisfactory on all rations. This finding provides one solution to the current problem of alfalfa-meal shortage on the eastern seaboard for the broiler industry.

In feeding experiments at the Virginia station, cooperating with the Department, with growing Rhode Island Red chicks the inclusion of 1 percent of ground acorn kernels and shells of the willow oak in a vitamin A-deficient diet was as effective in maintaining growth and viability as 108 micrograms of carotene in peanut oil per 100 grams of feed. Growth was retarded by the inclusion in the diet of 40 percent of acorns, but 20 percent and smaller amounts did not produce the unfavorable effects. Willow oak acorns were calculated to contain 180 International Units of vitamin A per gram.

The fat content of the diet significantly affects the utilization of carotene by hens, as demonstrated by the New Jersey station. The absorption of carotene in the crystalline form was about 60 percent of the consumption on a normal ration containing 3.83 percent fat for about 70 days, as contrasted with about 20 percent absorption of similar amounts of carotene consumed by hens on a ration with the fat extracted to 0.07 percent. Also, on normal rations hens absorbed more carotene as increased amounts were supplied, but not on the low-fat ration.

The vitamin D requirements of chicks is dependent on the dietary levels of calcium and phosphorus, as shown by the Maryland station. Optimum growth and bone ash to 3 weeks of age were obtained without vitamin D on rations containing 4.4 percent calcium and 2.2 percent phosphorus. When 5 units of vitamin D were added to a ration containing 3.6 percent calcium and 1.8 percent phosphorus, better growth, feed efficiency, and bone ash were induced up to 10 weeks of age than with 10 units of vitamin D in a ration containing 1.7 percent calcium and 0.85 percent phosphorus. Thus, when vitamin D supplements are difficult to obtain the deficiency can be largely offset by adjustments in the mineral content of the diet.

Supplying adequate amounts of the B vitamins for poultry.—The shortage of animal proteins, particularly milk products, which normally supplied a high percentage of the riboflavin and other members of the vitamin B complex in poultry rations before the war, has stimulated extensive research on suitable substitute sources of these essential dietary factors.

Further studies at the Maryland station confirmed earlier findings on the high value of a byproduct from the fermentation of molasses in the manufacture of butanol and acetone as a carrier of riboflavin and a substitute for dried skim milk for growing chicks and laying hens.

Whey solubles, a concentrate of whey (50 percent dry matter) from which most of the lactose and protein have been removed, proved to be a good source of pyridoxine and pantothenic acid, a fair source of niacin and riboflavin, and a poor source of choline in the chick ration at the Indiana station. Another product known as condensed fish-press water effectively supplements whey solubles. A simple ration containing 5 percent dry matter from whey solubles and 2 percent of the fish-press water, but no other animal products and no wheat or wheat byproducts, supported excellent growth in chicks.

Dried whey or primary-grown yeast proved to be excellent substitutes for dried skim milk in practical poultry rations at the Connecticut (Storrs) station.

The biological value of riboflavin in Korean and sericea lespedezas equalled crystalline riboflavin or riboflavin found in dehydrated alfalfa-leaf meal, according to South Carolina station findings. These lespedezas, which contain about as much riboflavin as a similar grade of alfalfa meal, may replace alfalfa in poultry-breeding rations. They are produced in the region more economically than alfalfa.

Distillers' dried solubles was found by the Indiana station to be a good source of water-soluble vitamins and a valuable supplement to corn and soybean meal for chicks. It could replace all of the dried skim milk in the starting rations of broilers or pullets.

The New York (Cornell) station, using natural basal diets of low pantothenic acid content for poultry, established that the requirement for good egg hatchability is between 1,200 and 1,700 micrograms of this factor per 100 grams of ration, whereas good livability and weight maintenance were secured at the 200-microgram level and optimum egg production at the 700-gram level. It appears that in ordinary rations this factor is likely to be too low for good hatchability, requiring the use of some potent source as a supplement.

Continuing studies of deficiencies in chicks diets, the Wisconsin station found that additions of nicotinic acid up to 1.5 milligrams per 100 grams of ration increased the growth of chicks up to 3 weeks of age. In another study there was a reduction from about 80 percent hatchability of eggs from hens on normal rations to less than 20 percent in 6 weeks of the eggs from hens on a purified diet. The missing factor was supplied by additions of 5 percent of whey concentrate, 3 percent kidney residue, or 15 micrograms of biotin per 100 grams of ration. These results demonstrate clearly the need of chicks for biotin. The need of vitamin B_6, or pyridoxine, for normal reproduction by laying hens was also demonstrated. Egg production, fertility, and hatchability decreased to practically 0 on the vitamin B_6-deficient basal ration, but hatchability was nearly 100 percent with the supplement of 4 milligrams of B_6 per kilogram of ration.

At the California station, chicks on a pyridoxine-deficient diet were found to show slow growth, convulsions, and other related abnormal conditions. When 2 milligrams of pyridoxine were added per kilogram of the ration, the growth rate was doubled and there were no convulsions, which began in some chicks on the basal ration at 12 days of age. It was demonstrated, however, that this deficiency is not likely to occur on a good practical ration. This station also found that turkey poults require roughly about 50 percent more of riboflavin, pantothenic acid, and pyridoxine than chicks.

MINERAL SUPPLEMENTS IN LIVESTOCK RATIONS

The importance of proper mineral balance in livestock feeding has long been recognized. A few examples of recent findings in this field follow:

A cobalt-deficiency problem in dairy cattle has been definitely established in certain sections of Michigan. In several commercial herds in which emaciation due to lack of cobalt had occurred, the response to cobalt supplements was marked both in gain in weight and increased milk production.

Phosphorus fed as a supplement to sheep during the breeding season was found by the Utah station to be effective in bringing about a better lambing performance, even though the animals were returned to the open-desert range and the supplement was discontinued. All animals, whether previously supplemented or not, had blood-phosphorus levels below the level for safety.

Similarly, the Idaho station found that ewes fed on low-phosphorus roughage (0.15 percent or less phosphorus) should be given free access to bonemeal, or other feeds high in phosphorus in order to insure a good lamb crop.

The general conclusion from tests at the California station indicated that deficiencies of phosphorus and vitamin A affect normal reproduction in sheep. Although depletions of vitamin A in the liver and of phosphorus in the blood are slow processes, they may occur in dry years and become a serious factor in lamb mortality. If a high-percentage lamb crop is to be maintained a ration low in vitamin A, protein, and phosphorus must be avoided.

An iodine-deficiency problem in Indiana livestock production is indicated in findings of the Indiana station. Examinations of the thyroid glands of over 200 young lambs from ewes fed supposedly adequate rations revealed that more than half of the glands were abnormally large, only 12 percent presented a normal histological picture, and practically none contained a normal amount of iodine. Further experiments are in progress to determine the seriousness of the problem and means of overcoming it.

Evidences of mineral deficiency accompanied by relatively slow gains were exhibited by fattening pigs allowed to graze on runner peanuts without mineral supplement, in trials at the Florida station. Simply supplying 2 grams per head daily of common salt improved the appetite as well as the rate of gain, while provision of a complex salt mixture containing sources of phosphorus, calcium, iron, copper, and cobalt in addition to salt gave increased benefits. It is concluded that to increase the yield of pork per acre of peanuts, it is of utmost importance that a mineral supplement be used.

Sources of phosphorus for poultry.—Shortages in the normal sources of phosphorus for poultry, particularly steamed bonemeal, has stimulated a search for suitable substitute sources.

Experiments recently completed at the Washington station indicated that defluorinated phosphate could be substituted for bonemeal as a source of phosphorus in poultry laying rations. Both with regard to production and eggshell quality, the defluorinated phosphate was found equal to bonemeal when fed to laying pullets at equivalent levels of phosphorus in the diet. These findings point the way to meet a rather acute problem in the compounding of poultry rations because of the decreasing supply of bonemeal for poultry feeding.

Phosphorus supplied as calcium phosphate was effectively utilized by chicks in experiments at the Maryland station. There was little difference in the efficiency of phosphorus utilization as measured by bone development when the supplement consisted of tricalcium phosphate, dicalcium phosphate, or calcium metaphosphate, provided each was fed in finely ground form.

Chicks receiving a ration of corn, wheat products, and soybean meal, which contains a rather high percentage of organic phosphorus as phytin, still required a reasonable amount of inorganic or nonphytin phosphorus for normal growth and bone development in experiments at the New York (Cornell) station. Apparently the phytin phosphorus was relatively unavailable even in the presence of vitamin D.

INCREASING ANIMAL PRODUCTS THROUGH CROSSBREEDING

The development of improved strains of animals through breeding is at best a long and often discouraging process, yet by constant effort distinct progress is made.

The production of crossbred progeny by crossing distinct breeds or strains offers a rapid means of obtaining superior animals for certain purposes because of the increased vigor of the hybrid offspring as compared with purebreds. For example, the Minnesota station found that the productivity of Shropshire ewes was increased from 11 to 18 percent when crossed to Hampshire rams, and the productivity of Columbia ewes was increased 28 percent when bred to Hampshire rams as compared with the results of purebred matings.

In the production of crossbred pigs involving crosses between Poland China, Duroc Jersey, and Berkshire breeds, the South Carolina station found that the greatest value of crossbreeding appears to be in the larger percentage of pigs raised, and that crossbreds were heavier at birth and weaning and reached market weight after a shorter feeding period.

Comparison of the morphological characteristics, egg production, and viability of reciprocal crossbred birds with purebreds of the Single-Comb White Leghorn, Single-Comb Rhode Island Red, Barred and White Plymouth Rock, White Wyandotte, New Hampshire, Australorp, Black and White Minorca, Ancona, Light Brahma, and Jersey Black Giant breeds at the Kansas station showed that crossbreeding stimulated the vigor of the progeny. An analysis of the performance of purebred and crossbred chicks gave evidence that crossbreeding tended to improve the hatchability of the eggs, viability of the chicks, rate of egg production, and growth. Based on this and similar find-

ings at the Arkansas station and elsewhere, the extensive use of cross-breeding for broiler production is now a well-established practice.

An improved strain of Broad-Breasted Bronze turkey males, when mated with standard Bronze, Bourbon Red, or Bronze-Black females, gave progeny of better breast conformation, earlier maturity, superior fattening quality, and greater fertility as compared with matings within the broad-breasted strains in trials at the West Virginia station.

USING HORMONES TO PRODUCE MORE ANIMAL PRODUCTS

From the extensive fundamental research on the function of specific hormones in the animal body and their interactions, certain findings have definite application in increasing livestock production.

An iodinated casein preparation developed at the Missouri station has been proved to possess definite thyroidal activity, and, in fact, will yield crystalline thyroxine on hydrolysis. This material, when administered to milking cows in appropriate dosages, increased milk production an average of 13 percent over untreated controls. It is now in commercial production and appears to have a place in the present situation which demands increased milk production.

In trials at the Tennessee station chicks showed a growth-stimulating effect from additions of small amounts of thyroactive iodocasein. Additions of 0.025 and 0.05 percent produced greater gains and the chicks required less feed per unit of gain up to 12 weeks of age than the controls. Feathering was more complete, in accordance with the amounts of thyroactive iodocasein present, up to 0.2 percent of the ration.

The Missouri, Minnesota, and New Jersey stations agree in their findings that the subcutaneous administration of the synthetic compound, diethylstilbestrol, will stimulate milk production in nonproducing virgin or sterile dairy cows. It appears practical to treat sterile heifers with this drug to bring them into production.

In trials at the California station implantation of 20 3-week-old Single-Comb White Leghorn cockerels with stilbestrol pellets produced an increase of 43 grams at 8 weeks of age over that of 21 untreated controls. Changes in body composition were also induced. This finding too appears to have a practical application.

KEEPING ANIMALS HEALTHY

The loss to livestock and poultry producers from diseases and parasites has been estimated at close to one-half billion dollars annually. Such losses are reflected directly in reduced supplies of animal products. Research continues to play an important role in pointing out ways to reduce these losses as indicated by the following examples.

INFECTIOUS DISEASES

Studies at the Wisconsin station have shown that the newborn calf needs exogenous sources of vitamin A, niacin, and ascorbic acid, since they have little reserve of these factors at birth. A combination vitamin A-niacin therapy has proved highly beneficial in helping to ward off navel ill, peritonitis, and scours in the young calf.

Continued studies by the Michigan station on the use of antiserum, both in prophylaxis and treatment of pneumonia in lambs, have estab-

lished the value of this practice in preventing high mortality from this disease among young lambs. The antiserum was collected from mature ewes which had been repeatedly injected with a bacterin prepared from micro-organisms isolated from lambs dying from pneumonia. These included members of the genera *Corynebacterium* and *Pasteurella*, together with some unidentified forms.

An infectious type of swine dysentery has been shown by the Indiana station to be due to a *Vibrio* bacteria which has been isolated in pure culture. Infection was produced experimentally either by feeding the pure culture or colon tissue from affected hogs. Further work remains to be done in establishing the common mode of transmission and methods of control.

Infectious enteritis in swine was found by the Minnesota station to respond favorably to the administration of sulfaguanidine. The drug usually was administered for 6 to 8 days, the animals as a rule showing marked improvement by the third to fifth day. Similarly, the Michigan station showed that sulfaguanidine was effective in protecting pigs against infection from inoculation with *Salmonella choleraesuis*, the principal bacterial invader associated with **hog cholera.** Following the initial setback from such treatment, nicotinic acid in the diet was effective in promoting rapid recovery and in increasing gains.

In further attempts to develop an improved immunizing agent against **brucellosis or infectious abortion** in farm animals, guinea pigs were immunized successfully at the Michigan station with a killed-culture type of vaccine prepared by carefully controlled methods. The vaccine is being tested cooperatively on cattle in commercial dairy herds. This method, if successful with cattle, would have great advantage over live-culture vaccines, even those of known low virulence, since there can be no danger of infection of the animal from killed-culture vaccines.

Control of anaplasmosis of cattle has been one of the most perplexing problems confronting the research worker. Experimental results at the Oklahoma station indicate that tryparsamide, neosalvarsan, and cobalt chloride have distinct possibilities in the treatment of anaplasmosis. Biting flies appeared to be the main vector in the transmission of this disease in the grazing areas of northern Oklahoma.

Mastitis continues to be one of the most prevalent disorders of dairy cattle and most devastating from the standpoint of reduced milk yield. Reports from the Delaware, Florida, and Idaho stations concur in showing that sulfanilamide powder suspended in light oil and transfused into the infected udder through the teat canal is highly promising in combating mastitis. A high percentage of acute, chronic, and latent infections of the udder were successfully eliminated by such treatment. The importance of careful sanitary precautions, including segregation of infected animals, careful washing of the hands after milking each cow, or sterilization of the teat cups after milking each cow in the case of machine milking, and general cleanliness on the milking premises as aids in controlling mastitis have been reaffirmed by the Connecticut (Storrs) and Florida stations.

A possible new approach to mastitis control has been advanced by the Colorado station. Complete starvation for 5 days, but with the cow given all the water desired, resulted in disappearance of clots,

flakes, and pus from the milk, return of mastitis milk to normal acidity, lowering of chloride percentage of milk, and improvement of milk production and condition of animal in current and succeeding lactation periods. Since milk and fat production were not adversely affected and the general condition and appearance of animals were improved, such an inexpensive procedure may prove especially valuable as a herd-management practice for each cow once per lactation period in serving to check the appearance of mastitis and save affected cows for future production.

New evidence on the action of milking machines upon the udder and rate of milking by the Minnesota station led to recommendations for speeding up milking with a consequent reduction in injury to the udder and teat. The station believes that if the recommendations are followed incidence of mastitis will be reduced.

INTERNAL PARASITES

Internal parasites, particularly those infesting the gastrointestinal tract, are prevalent in most classes of livestock and cause loss through reduced vigor and productivity of the animals.

A detailed study of the cycle of infestations and damage in sheep by various types of intestinal parasites by the Virginia station gave evidence that lambs born in late winter remain comparatively free from parasites until July, which makes the marketing of lambs around July 1 desirable. For animals retained in the flock after July 1, treatment consisting of 2 dosages of phenothiazine in July, a third in late November, and a fourth in late winter is recommended to control the various types of parasites which are seasonally prevalent.

From a study of gains made and parasites found after slaughter, the North Dakota station concludes that lambs from farm flocks should be treated when put into feed lots. Phenothiazine was most effective, yet copper sulfate was nearly as good and much cheaper.

In California, the widespread use of irrigated pastures for lamb feeding has intensified the problem of parasite control. The California station studied the possibility of reducing costs and labor requirements involved in treating sheep individually by giving the lambs access to a mixture of 1 part of phenothiazine in 15 parts of half-ground salt. Extensive trials show the mixture to be nontoxic when fed for 78 days, and that feeder lambs carried through the pasture season with no other form of anthelmintic treatment than 1 to 15 parts of phenothiazine and salt kept before them every other month, are marketable as fat lambs as soon or sooner than lambs dosed with copper sulfate-nicotine sulfate mixture every 4 or 5 weeks. The phenothiazine-salt mixture should be used only as a preventive measure, and heavily parasitized lambs should be treated first individually with one of the standard treatments.

Results of an experiment just completed by the Colorado station shows that waste of livers can be prevented by properly drenching feed-lot lambs to combat fringed tapeworm, a parasite that causes a high percentage of condemnation of lamb livers. Such livers weigh about 2 pounds each, and Colorado produces more than a million feed-lot lambs yearly.

The importance of good management practices is borne out by a report of the South Carolina station that swine raised under sanitary

conditions gained faster and cheaper and had fewer internal parasites than those raised under insanitary conditions.

A bio-assay technique for evaluating anthelmintics based on the ability of a drug to counteract artificial inoculations of *Nippostrongylus muris* in albino rats, has been developed by the Kansas station. This promises to be of marked value in determining rapidly the merits of new chemicals in the treatment of certain internal parasites.

The Montana station has found that feeder lambs limited to prairie hay for several days before being placed on a fattening ration of alfalfa, beet pulp, and oats were much less subject to coccidiosis than those started at once on the fattening ration, which is in line with an earlier report from the Colorado station.

In Wisconsin station experiments chicks getting plenty of feed in early morning suffered only about one-third the losses from coccidiosis as birds that were not fed until 8 a. m. It is concluded from this that full-feed hoppers help prevent the disease. Keeping floors and yards dry was also an important factor in minimizing losses.

A disorder closely resembling blackhead of turkeys in broilers kept under farm conditions has been reported by the Arkansas station. Organisms similar to *Histomonas meleagridis*, the causative agent of turkey blackhead, were present in cecal and liver tissues of the infected broilers. Chicks experimentally infected with *H. meleagridis* made relatively poor growth as compared with healthy controls. Sanitary measures and the elimination of cecal worms and prevention of coccidiosis appeared to prevent the spread of this infection in the flock.

A high vitamin A content of the ration increased the resistance of chickens and turkeys to trichomoniasis, according to the Missouri station. This type of infection has increased rapidly in recent years. A diet of ground oats fermented with yeast and fortified with cod-liver oil was quite successful in controlling an outbreak.

EXTERNAL PARASITES

Cattle-grub infestations have reached serious proportions in certain of the Great Plains States. According to records of the Nebraska station, 85 percent of the cattle slaughtered during the first 3 months of 1943 were infested and more than 61 percent were classed as grubby, i. e., more than 5 grubs per animal. On this basis, the annual loss in value from the hides of cattle slaughtered in Omaha amounts to more than $500,000. The station is acquainting cattle growers with effective control measures.

In view of the limited supplies of rotenone and pyrethrum, heretofore used effectively in lice control, the North Dakota station studied the value of possible substitutes. When phenothiazine was diluted with equal parts of white flour and applied to cattle infested with sucking lice a 100-percent mortality of the lice resulted in every trial. A mixture of sodium fluosilicate 2 parts, phenothiazine 1 part, and white flour 1 part, gave excellent control of both sucking and chewing lice. An effective cheap powder of 0.5–1 percent nicotine dust with sulfur also controlled both sucking and chewing types of lice, and proved as satisfactory as pyrethrum.

Wartime poultry production should benefit from the discovery by the Kentucky station that the use of nicotine sulfate on roosts controls

chicken lice better when the temperature is under 50° F. than at higher temperatures. The farmer should clean up his birds and houses in cool weather and not wait until summer when chances of success are reduced.

POISONOUS PLANTS

Discovery of a new poisonous plant by the Nevada station explains the cause of heavy losses of sheep on the range. *Halogeton glomeratus*, a comparatively recent plant introduction which has been used to some extent in range revegetation but not previously recognized as poisonous, caused death of sheep in experimental feeding due to high concentration of oxylates, thus establishing the cause of sheep losses running into large numbers over recent years. Local distribution of the plant was mapped by quick survey and plans for using it in reseeding ranges were promptly abandoned.

An investigation by the Texas station of losses in horses that have occurred for many years in various parts of the State gave evidence that grazing on whitebrush (*Lippia ligustrina*) results in a toxic effect from which the animals eventually succumb. The symptoms consisted of leg weakness, incoordination, and emaciation. Calves kept in the same experimental pasture developed a similar emaciation but no other evidence of toxic effect, while sheep and goats suffered no ill effects.

Tung tree foliage, when fed to cattle at the Florida station, proved to be highly toxic. Animals consuming either the green or partly dried foliage died within a period of 3 days to 4 weeks. The problem was brought to the station's attention through the death of 14 purebred cattle that had eaten foliage from tung trees which had been discarded in a pasture.

CONSERVATION OF FOOD RESOURCES

With food production greatly increased in quantity and improved in quality as discussed in the previous sections of this report, the responsibilities of the experiment stations in meeting wartime problems of agriculture are only begun. Spoilage must be prevented through proper means of transportation and storage, and the means taken must be such as to retain to the greatest possible extent the nutritive value as well as the quality of the foods. With increasing quantities of foods earmarked for the use of armed forces overseas and for Lend-Lease shipments, the preservation of foods in reduced bulk introduces entirely new problems of preservation. Possibilities must be explored for new or substitute sources of essential nutrients. Food-crop planning on a large scale and for home gardens and home food purchases and preservation must be considered in terms of nutritive value. To help in diet planning more knowledge is needed of nutritive requirements, food habits, and nutritional status.

BETTER METHODS OF FOOD PRESERVATION

The most urgent wartime problems in food preservation on a large scale have been those involved in shifting from canning to dehydration and in improving dehydration procedures to yield products that are not only palatable when freshly dehydrated but retain their qual-

ity and nutritive value when exposed to the extremes of climate in overseas use. Interest in home dehydration has resulted from shortage of canning equipment and supplies and this shortage has also led to renewed interest in frozen-locker storage and a revival of earlier methods of preservation.

HOLDING AND COLD STORAGE

Emphasis on the problems involved in the large-scale processing of foods, particularly for overseas shipments, has somewhat overshadowed the problem of supplying the civilian population and to some extent the armed forces in this country with nonprocessed foods of highest quality and nutritive value.

Refrigeration for holding vegetables.—Retail holding of vegetables under poor conditions may be responsible for greater deterioration in quality and nutritive value than long-distance transportation under proper icing and refrigeration. The retention of ascorbic acid in vegetables has been shown by the New York stations (Cornell and State) to be a good index of retention of quality and nutritive value. With this in mind, the Wisconsin station has followed the ascorbic acid retention in chard, lettuce, spinach, broccoli, and green beans during various conditions of storage. Packing the vegetables in crushed ice as soon as harvested in the field was found to be an effective means of preventing deterioration during transportation and storage, this type of storage combining the protective factors of humidity and low temperature. Vegetables so packed retained their desirable qualities of color, weight, and freshness. Retail refrigeration of either the mechanical, ice, or crushed-ice display-case type was found satisfactory for retarding losses in vitamin C and retaining quality, the best results being obtained when the vegetables were placed directly on ice. Moisture without refrigeration, a practice followed in many retail stores, afforded no protection. The Wisconsin investigation emphasized that proper conditions of both humidity and temperature should be maintained from the time the vegetables are harvested until they are used.

Retaining quality in eggs.—The value of oiling fresh eggs, with particular reference to the optimum time of oiling, as a means of maintaining interior egg quality during storage has been investigated by the Washington station. Eggs oiled either on the day they were gathered or on the following day were definitely superior in keeping quality to those not oiled, but oiling on the third day or later was of little value. Oiling eggs within a few hours after they were laid resulted in excessive liquefication of the firm albumen, although such eggs otherwise had superior keeping quality. Eggs oiled the day after gathering were superior to those oiled earlier, or left unoiled, when all criteria were considered.

By subjecting eggs to the proper temperature the Missouri station found that the embryo can be destroyed and the albumen stabilized so that treated eggs retain their commercial grade in storage much longer than untreated eggs. The process is thought to have great commercial possibilities in prolonging the feasible storage period and also for holding eggs for considerable periods at atmospheric temperatures without spoilage. Extensive tests conducted by the station in cooperation with the War Department on untreated and treated

eggs shipped from Missouri to California and kept under desert-temperature conditions confirmed the laboratory tests in showing a definite superiority of the treated eggs. The process, which has been given the name thermostabilization, consists in raising the temperature of the eggs for a short time to 140° F., preferably by immersing them in still or circulating oil at this temperature.

From comparisons made by the Utah station of the successive daily ratings of eggs kept for a week according to various home practices, first place was given to eggs stored in the hydrator of a refrigerator, followed in descending order by storage in a closed container in the refrigerator, an open container in the refrigerator, and a closed cardboard carton on a shelf in the kitchen cupboard. Of the two extremes, 95 percent of grade A eggs kept in the hydrator had dropped to B grade by the end of the week, while 96.7 percent of those kept in a carton in the kitchen cupboard had dropped to C grade and the rest had to be graded as rots.

CANNING

Commercial fruit and vegetable cannery operations.—Problems confronting South Carolina fruit producers and canned-fruit consumers are the low prices paid for the raw products and high prices for the canned. The South Carolina station has pointed out that the average commercial cannery in the State operates only 55 days a year and at only 23 percent capacity during that time. Increase to 60 percent capacity without lengthening the canning season would enable a 25-percent increase in prices for raw products without affecting profits. Data collected by the station in pilot-plant operations in the canning of peaches show that it takes less labor to can large peaches than small, the yield is greater, and fewer man-hours are required for pitting and packing. Costs per case, based on costs of labor and fruit, are accordingly less for the larger fruits.

Nutritive value of commercially canned foods.—Laboratories of the Arizona, Pennsylvania, and Wisconsin stations were selected by the Nutrition Committee of the National Canners Association among five chosen for an intensive program of research on the vitamin content of canned foods processed by representative canning companies in various sections of the country. A wide variety of commercially canned fruits and vegetables was collected by representatives of the association from different parts of the country and sent to the various laboratories for analysis. Carotene and ascorbic acid determinations were made at the Arizona station and thiamine and niacin at the Wisconsin station. The effect of storage for different lengths of time and at different temperatures on the content of carotene, thiamine, riboflavin, and ascorbic acid in the canned food was studied by the Pennsylvania station, which was also responsible for comparisons of different methods of assay. In view of the wide use of canned foods in feeding the armed forces of the United Nations and possible deterioration of the products in various climates, the project is of immediate war application. The results of the first year's work have been reported to the National Research Council and through this organization to the groups most interested in the findings.

Wartime food-processing aids.—For Colorado residents who do not have pressure cookers the Colorado station has developed pro-

cedures for acidifying nonacid vegetables with citric acid or vinegar, preferably the former, preliminary to canning by water-bath methods. In recommending these procedures, the station warns against careless processing and sealing and emphasizes the necessity of invariably boiling home-canned vegetables for 15 minutes before tasting.

SULFURING

Preserving fruits with sulfur dioxide for overseas shipment was investigated at the Georgia station through the cooperation of TVA, United States Department of Agriculture, and the British Food Ministry and found to be an efficient and economical means of preserving peaches, strawberries, youngberries, blackberries, and other fruits and pulps. Generally, some calcium salt is added as a firming agent. Different salts are more effective with different fruits. Thorough and repeated mixing of the fruit with the preservatives is necessary, and different times (from 2 to 24 hours) are required for complete penetration, depending upon the kind of fruit, degree of ripeness, and firming agent. In the use of SO_2-treated fruits for preserves, the preservative can be removed sufficiently by boiling in a steam-jacketed kettle for 20 minutes, a covered stewpan for from 45 to 60 minutes, or in an open kettle for from 60 to 120 minutes.

DEHYDRATION

The urgent need for saving shipping space in Lend-Lease shipment of food to other countries and the lack of suitable equipment for canning are largely responsible for the rapid and extensive expansion of research on dehydration at the experiment stations. The 1943–44 programs of work show dehydration projects on a commercial or home scale, or both, in 27 States. These are not simply engineering projects confined to construction and operation features but for the most part involve active participation by several station departments in addition to engineering—horticulture and animal or poultry husbandry for the selection of the products for dehydration, home economics for testing the quality of the dehydrated products, home economics or chemistry for checking on losses of nutritive value, and in some instances, bacteriology for determining the keeping qualities of the products with regard to microbiological changes, and agricultural economics for the marketing aspects.

Large-scale dehydration problems, to the solution of which the experiment stations are contributing, have included the conversion on the west coast of the older sun-drying processes for fruits to more rapid and reliable dehydration; the conversion of canneries in various sections of the country to dehydration plants; and the development of satisfactory large-scale methods of dehydrating certain foods particularly desired by the Army.

Conversion of canneries to dehydration plants.—In face of the tremendously increased demand for dehydrated foods for the armed forces, the Oregon station estimated that at least 200 dehydration plants in addition to the 120 already completed will be required to meet the production needs in the State. The station has pointed out to canners that the processes for dehydration are not so very different from those of canning and that the change-over can be made with minimum effort.

Anticipated shortages of canning equipment by commercial canners led the Maryland station to undertake an emergency project to obtain basic data on the possibilities of dehydration for a number of important crops in the State. First a small electric cabinet type of dryer was built and then two tunnel dehydrators were designed making use of data obtained with the small dryer for pilot-plant tests. Basic dehydration data were obtained for several crops, particularly sweetpotatoes, and these tests combined with reconstitution and quality tests have enabled the station to make recommendations to dehydration enterprises on a commercial scale.

Dehydration of fruits offers important wartime advantages.—Because of the many advantages of dehydration over sun-drying in the saving of labor, time, and equipment, and in the keeping quality of the product through the greater reduction of moisture content, the dried-fruit industries on the west coast are to a great extent substituting dehydration for drying and have benefited from the research of the California station in fruit-dehydration problems.

Proper blanching of the cut fruit as a preliminary step before sulfuring was found by the station to give products equal in color and translucency to the sun-dried. Fruits thus blanched retain more SO_2 than sun-dried and this leads to less reduction of carotene and ascorbic acid than takes place in sun-drying. Dried prunes of fresh-fruit color, of higher vitamin C and A content, and of much better flavor than the usual dried prunes were produced by steam blanching before drying. Pretreatment with sugar and sirup was found desirable in the case of some cut fruits as an aid in the retention of SO_2, color, and flavor. Good procedures have been established for drying miscellaneous fruits such as pineapples, huckleberries, strawberries, loganberries, currants, bananas, persimmons, table plums, and cherries.

A problem of great importance to the Army is to find means of preventing the rapid blackening of dried fruits resulting from exposure to high temperatures in tropical and desert areas. The California station found that the SO_2 content of dried apricots stored at 95°–120° F. rapidly disappears, presumably by auto-oxidation, and that when it drops to a certain level, which varies with the previous history of the fruits, nonenzymic darkening occurs. Redrying to low moisture content and heavy impregnation with SO_2 or acid salts of SO_2 appear to be practicable preventive measures.

Sulfuring aids in vegetable dehydration.—Procedures for dehydrating vegetables and fruits are coming closer together with the discovery that steam blanching, hitherto used chiefly for vegetables, improves the quality of dehydrated fruits and that sulfuring, previously used only for certain fruits, helps to retain the original color and flavor of vegetables. This procedure, suggested and tested by the California station, has been found to prevent to a great extent the carotene and ascorbic acid losses which have been of great concern to those responsible for planning diets for the armed forces overseas. In the station tests, satisfactory levels of SO_2 (not high enough to affect taste but sufficiently high for protection) were obtained by dipping the blanched vegetables for not over 15 seconds in sodium bisulfite or potassium metabisulfite solutions of 0.25- to 0.50-percent concentration. The disagreeable hay flavors often de-

veloping in cabbage and carrots were definitely held in check even when stored in air in sealed containers at 90° F. The process has proved so effective with cabbage that sulfuring is now being included in the Army specifications for dehydrated cabbage.

Dehydrated sweetpotatoes.—Cooperative research among the southern stations on sweetpotatoes made possible a concerted attack upon the problem of meeting to a large extent the 1943 estimated requirements of the Army for 52,000,000 pounds of dehydrated sweetpotatoes, a demand exceeded only by white potatoes. The definitely outlined cooperative experiment on sweetpotato production by the Mississippi, Georgia, South Carolina, and Texas stations with the United States Department of Agriculture under way for the past 3 years has served as the basis for recommendations to growers for meeting the unprecedented demands for dehydration.

Plans were made early in the season in the various sweetpotato-growing States of the South to fill the above-mentioned order. The acreage devoted to sweetpotatoes was increased in every State and new dehydration plants have been under construction wherever possible. Six new commercial dehydration plants have been put up in Georgia alone, two or three new ones in Texas, Louisiana, and Mississippi, and one in Alabama. The very definite contribution to the program made by the Louisiana station in the breeding of a new sweetpotato, Unit 1 Porto Rico, is discussed in the section dealing with new food crops. Of particular value in the use of this strain for war-feeding purposes is its exceptionally high content of carotene.

The Alabama station is taking the lead in devising new and varied ways of using sweetpotatoes dehydrated by a process developed at the station and given the name "Alayam." The 20 or more "dishes" already developed with Alayam as a base range from candy bars to breakfast foods.

Egg dehydration.—The enormous supplies of dehydrated eggs required for Lend-Lease shipments and for the armed forces overseas, and the urgent need for dehydrated products that will withstand extremes of temperature and reconstitute satisfactorily, have led a number of the stations to conduct research on various phases of the problem. In the light of the national effort in 1943 to secure 250 million pounds of dried eggs, some of which must endure tropical temperatures up to 140° F. in combat zones, it becomes important to know the effect of processing and subsequent handling and storage under different conditions on the nutritive and other properties of the dried product.

Iowa being one of the major egg-producing States of the Union, the Iowa station has given special attention to a study of egg production and processing in relation to transportation requirements, costs, prices, and civilian and military Lend-Lease needs. Information derived from these studies was of assistance in locating 10 or 12 new egg-drying plants in the State, which, added to the two in operation early in 1942, will have an estimated capacity of 40 to 50 million pounds of dried eggs.

According to an estimate from the Georgia station, five of the Southern States will produce 17,300,000 pounds of dehydrated eggs in 1943, practically all of which will be shipped to the armed forces and to other countries under Lend-Lease. The station has pointed out that

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dehydrated eggs are as good for bakery purposes as frozen or fresh eggs, but that they should always be rehydrated for such purposes by mixing with lukewarm water in the proportion of 2 parts of unsifted egg powder to 2½ parts of water.

The thiamine, riboflavin, pantothenic acid, and vitamin A content of eggs dried at different temperatures and to different moisture contents has been determined by the Kansas station. Although the rest of the vitamins were reasonably stable for 6 months or more, thiamine was rapidly destroyed at ordinary temperatures at the usual moisture content of 6 percent. However, thiamine values were retained far better when the moisture content was lowered to 3 or 4 percent and the dried egg was stored at lower temperatures.

A study by the Indiana station of the vitamin A and carotenoid content of whole eggs and of whole-egg powder dried by the spray process showed practically no destruction of these constituents due to drying. Little loss in vitamin A potency occurred during storage at −18° or 6° C. for 6 months while at 20° or at room temperature some deterioration of the vitamin A took place. Rapid spectroscopic methods for measuring these characteristics were developed which gave values in close agreement with biological response.

Whole-milk powder.—The heating of milk to 170° F. for 30 minutes before condensing, the addition of antioxidants to the milk, the use of equipment which prevented copper contamination, and the reduction of the final moisture content to less than 5 percent were highly important steps in producing whole-milk powder of good keeping quality, according to findings of the Illinois station. Hydroquinone and gum guaiac were the most effective antioxidants tested. Ascorbic acid and sodium citrate were reasonably good antioxidants, while tyrosine, oat flour, and bacterial cultures were of some value in this respect.

Dehydrated baked beans—New England and California styles.—A process for dehydrating baked beans developed by the Massachusetts station has yielded such an acceptable product that the Quartermaster Corps has issued specifications based on this process for dehydrated baked beans for Army purchases. The beans are baked with salt pork and a well-seasoned brine, dehydrated (after discarding the pork) in a forced-circulation hot-air tunnel dehydrator at 140° F. for about 8 to 10 hours to a moisture content of 3 to 4 percent, and finally packaged in moisture-vapor-proof containers. Satisfactory rehydration requires soaking for 1½ hours in water 2 to 1.

The California station has experimented with the dehydration of cooked beans of different kinds and varieties either with or without flavoring ingredients. Among the kinds tested, the Garbanza ranked highest in retention of its flavor without cracking or bursting during cooking. The pink, pinto, lima, and other white varieties were of pleasing flavor. An excellent California-style product was made by soaking pink beans, cooking them with tomato hot sauce, onions, and a little garlic, removing the liquid, dehydrating the beans until nearly dry, and then mixing the liquid with the sauce and completing the drying. Dehydrated white beans, New England style, and pink beans, California style, are said to be satisfactory for eating out of the hand in the dry condition as are also dehydrated Garbanza beans.

Fruit and other bars for Army field rations have been developed by the California station in cooperation with the Quartermaster Corps. The principal problems are the hardening of bars as they dry out in the field, and fermentation in humid atmospheres. Use of invert sirup or raisins overcomes hardening and pasteurization and use of SO_2 prevents fermentation. Difficulties exeprienced by commercial packers can be avoided by use of the data worked out by the station. No satisfactory bar was developed in which dried nut meats were used as one of the ingredients, but several formulas using ground, precooked dehydrated soybeans or navy beans, powdered milk, and dried fruits plus a binder of fondant or invert sirup were found quite satisfactory as fruit bars to provide vitamins, calories, protein, and minerals.

"How to dehydrate food at home" is the title of a folder—illustrated in color—based on research information furnished by the Georgia, Tennessee, and Virginia stations in cooperation with the TVA and a commercial power company. The subject matter was submitted to and approved by some seven other State experiment stations in the South, and the folder has been very widely distributed by the extension services of the States involved. In other stations throughout the country home dehydrator plans have been developed and distributed within the State.

In studies of home dehydrators for vegetables, the California station has found that forced-air flow is essential for rapid and efficient drying and that recirculation of air is necessary for greater efficiency and maintenance of temperature. Field studies made under commercial conditions showed that little drying occurs in the first half of tunnels and that two-stage drying will prevent much waste of time and facilities.

A simple dehydrator built of noncritical materials and employing electric-light bulbs as a source of heat has been developed at the Indiana station. The main point of difference between this unit and other simple tray driers is the arrangement of baffles whereby air is forced through the trays rather than across them.

At the Massachusetts station construction details have been prepared for two types of small home dehydrators of simple design adapted for operation over the gas or electric stove unit and for a slightly larger dehydrator suited to the dehydration of quantities sufficient for several families.

In the interest of wartime conservation of materials, an iron-wire home dehydrator has been developed by the Washington station that does not include a fan for forced draft or thermostatic heat control but depends upon the radiant-heat principle to secure equal distribution of heat. Every tray is subjected from above to infrared heat radiated from iron wire stretched over the tray and from below to hot air rising from similar wires below the tray. The heated air passing over the food picks up moisture from the material to be dried and its movement is controlled by adjustable slides and small openings at the top and bottom of the cabinet. The wire used is ordinary No. 19 black stovepipe wire, Washburn and Moen gage. The 2 pounds of wire required and the few other items of hardware needed cost only about $5. In a bulletin issued by the station complete directions are given for making and wiring the dehydrator.

FROZEN STORAGE

Research on the preservation of foods by quick freezing both in large-scale freezing plants and in frozen-locker storage plants continues in spite of present interest in dehydration.

More economical use of freezing facilities.—Difficulties in expanding existing facilities for quick freezing have led to studies of ways and means of increasing present freezer-plant or locker capacity An important finding of the work on freezing storage at the California station is that the capacity of quick freezers of frozen-pack plants can be doubled or trebled by partially quick freezing and then removing to storage at −10° to +10° F. This procedure does not injure texture or quality and releases the quick freezer for another load.

The more nearly full a freezer locker is kept the lower the carrying charge per pound of frozen food, the Pennsylvania station has concluded from a survey of freezer-locker utilization in the State.

Another means of making more economical use of limited locker space is suggested by the recommendation of the Illinois station that in order to conserve space only such cuts of meat be placed in lockers as do not lend themselves to other means of preservation. The station advises that bony cuts of pork be used fresh and that hams, bellies, and picnics be cured and smoked, thus leaving from the average of 110 pounds of meat from a 225-pound hog only 45 pounds of fresh pork for locker storage. Another recommendation is that all beef for the locker be boned. Conservation of space in locker storage through careful planning for the replacement of foods as they are used and space is released will extend the capacity of locker space, but recommendations for such planning will of necessity vary with the locality.

The Colorado station has shown the feasibility, from the standpoint of quality and nutritive value, of storing carrots in trenches during the winter and freezing any surplus that may be left in the early spring, by which time space in lockers is usually available. This recommendation is based on studies showing that it is not until late spring under Colorado conditions that trench-stored carrots deteriorate in quality and nutritive value. While most recommendations for freezing vegetables call for the establishment of freezing plants not far from where the vegetables are grown, the station has found that under Colorado climatic conditions it is perfectly feasible to transport vegetables for freezing several hundred miles if the usual methods of icing are used.

Preserving quality in frozen foods in locker storage.—Four rules have been formulated by the Iowa station for the use of locker patrons, as follows: (1) Select for freezing those vegetables that have flourished during the current crop season and acquired an excellent texture and flavor; (2) be prompt about processing products for freezing, making necessary arrangements in advance so that fruits and vegetables can be prepared and frozen before they have a chance to wilt or deteriorate; (3) select kinds of fruits and vegetables that freeze well, and the correct varieties; and (4) follow closely the directions for scalding vegetables.

One of the problems concerning quality in the use of frozen-locker storage for meat is the length of time the meat can be thus stored without deteriorating in flavor. Studies by the Indiana station on changes in beef during frozen storage indicated that while chemical

decomposition, rancidity, and tissue changes developed slowly in storage, the extent of change during 15 months was not sufficient to seriously affect the quality and palatability of the meat.

Results of tests by the Washington station on the effect of locker storage at 0° F. on the quality of various cuts of pork and pork sausage showed no significant loss in quality within the 4½ months of the study, although the roasts were somewhat less tender at the end of the period than after only 1½ months of storage.

The selection of containers and wrapping materials is another factor affecting quality in the frozen product and one of considerable concern at the present time when certain of the newer materials are no longer available. A study by the Georgia station involving more than 5,000 weighings to determine moisture losses over a period of a year from 5 frozen products (2 fruits and 3 vegetables) packaged in approximately 100 kinds and combinations of materials showed that any of the untreated cartons or wrapping materials tested could be made moistureproof by the use of paraffin alone. One such film was found to be enough, whether applied to the liner, the carton, or the wrapper. Additional layers of impervious material added to the bulk and weight of the package without contributing much to its efficiency.

Frozen cream as a source of fat in ice cream.—In tests of the development of off-flavors in frozen cream, the Florida station found Avenex, Avenex concentrate, and trypsin to be effective antioxidants in concentrations of 1.5, 0.1, and 0.003 percent, respectively. Homogenization, additions of ascorbic acid, hermetic sealing of the can, or a surface layer of ice were of doubtful value in the prevention of oxidized flavor in the stored product. Ice cream of satisfactory quality was made of frozen cream which had been stored up to 7 months at 0° F.

The use of frozen cream as the sole source of fat in ice cream was found by the Michigan station to retard the whipping ability of the mix, but there was no difference in the time required for a 90-percent overrun for frozen cream held 1, 3, or 6 months, and the body and texture of the ice cream were not altered. A 90-percent overrun was obtained more easily when 10 percent sucrose was added to the cream before freezing for storage. The delayed whipping with frozen cream was largely overcome by the addition of 0.35 percent dried egg yolk to the mix and this also seemed to improve the flavor slightly and maintain a good flavor over a longer storage period.

Frozen eggs for retail distribution.—A system for freezing eggs (either mixed whole or separated white and yolk) in a form suitable for retail distribution and convenient for the home was developed by the Michigan station through the comparatively simple process of freezing the cooled egg material in trays equipped with grids so constructed as to furnish the desired size of units. To prevent the frozen eggs from sticking to the metal it was necessary to line the trays with pliofilm or cellophane and to coat the grids with a thin coat of ice. Thus prepared, the frozen-egg package permits the removal of any given number of eggs without the necessity of thawing, the number desired being determined by counting rather than by measuring or weighing. The time required for thawing was short, about 10 minutes at room temperature. For distribution of the frozen eggs in this form

it is essential to use good shell stock, candle thoroughly, maintain bacteriological cleanliness, and have plenty of refrigeration and properly designed equipment and laboratory control.

New frozen products.—Quick-frozen **ripe olives** of the Mission variety were found by the California station to be very similar in texture to freshly picked olives of the same variety, but other varieties tested were not so satisfactory.

The California station has also devised new methods of preparing **baby foods** for frozen pack. The products are said to be superior to the canned in flavor and color and in retention of thiamine.

Tender **sugar beet tops,** shown in studies of the Colorado station to make excellent greens with a high vitamin content, are recommended by the station for preservation by quick freezing.

SUBSTITUTE, NEW, AND IMPROVED SOURCES OF NUTRIENTS

At a time of shortages of certain foods, knowledge of the comparative values of different natural sources of specific nutrients makes it possible to substitute one source for another. Similarly, information on the nutritive value of unaccustomed foods may lead to a greater use of such foods with consequent sparing of the more familiar sources. Finally, the possibility of enriching staple foods in the constituents which they lack offers a means of increasing the nutritive value of deficient diets.

PROTEIN FOODS

With probable meat shortages and restrictions under point rationing it becomes more essential to make use of vegetable proteins to the greatest possible extent.

Soybeans, a valuable supplementary source of protein.—Recent experiment station research on the value of soybeans, both in the green vegetable and mature forms, published as a symposium, includes reports from the Alabama, Tennessee, Illinois, and Wisconsin stations. In the Alabama report, it was emphasized that although soybeans are not a complete substitute for milk, meat, eggs, and cheese, they can serve as a valuable supplementary source of protein. From analyses made at the station it has been calculated that a 100-gram serving of mature soybeans would supply 40 percent of the protein, 25 percent of the calcium, and over 60 percent of the iron required by an adult for a day. It was also pointed out that not only is the protein content of the soybean nearly double that of other beans and peas but the quality of the protein is superior.

The extent to which soybeans contributed to locally produced home food supplies in a subsistence project was reported from the Tennessee station. Partly because of traditional habits of the families of using large quantities of breadstuffs and baked goods, more than half of the soybean consumption was in the form of locally ground meal used in breads. Some use was made of canned green or vegetable-type beans. Two of the families reached an annual consumption of soybeans in all forms of 35 pounds per adult-equivalent.

A report from the Illinois station makes a distinction between the contributions to the diet of soybeans in the green and mature forms. In the young green stage, they add variety to the limited list of green vegetables available in the early fall; and in the mature stage serve

as a valuable protein supplement. Average protein values of 12 varieties of green soybeans and 14 of mature soybeans were given as 12.25 and 40.57 percent, respectively. Freezing was reported to be a much more satisfactory method than canning or drying for preserving green soybeans.

The Wisconsin station report emphasized the increase in nutritive value of the proteins in soybeans by moist-heat cookery.

Other seed proteins.—Among other plant-protein sources tested by station workers are **pinto beans,** found by the Colorado station to be as efficiently used as a source of protein by college men as the commonly used animal proteins; the **Idaho field pea** which the Idaho station reports from studies on rats to be a good protein source except that it is lacking in one of the essential amino acids, methionine; and **peanuts,** which, also on the basis of rat-feeding tests, the Georgia station has shown to have biologically complete proteins although not quite as efficient in promoting growth as the proteins of milk. The Idaho investigators suggest that by using the field pea and eggs at the same meal the deficiency of methionine in the peas can be made up, as eggs are a good source of methionine.

Corn germ, at present used principally as animal feed, gives promise of serving as a useful source of protein for human consumption, according to tests at the Illinois station. The germ, defatted by a commercial extraction process which reduces the fat content to about 2 percent and the moisture to 8 percent and gives a very palatable product, was found to contain 21 percent protein which was 85 percent as digestible as beef protein and of equally high biological value. In fact, preliminary reports indicate that the protein of the defatted corn germ has the highest biological value yet obtained in the station laboratory for a vegetable protein. The defatted corn germ is also high in thiamine (25.6 milligrams per gram) and iron (300 parts per million). The expediency of introducing the food material into the human diet is suggested by the station.

NEW AND UNUSUAL SOURCES OF VITAMINS

When one or another of the vitamins is not obtainable by the civilian population from conventional sources because of wartime demand, reliance may well be placed on more unusual sources.

The **buffaloberry,** a native fruit of North Dakota, has been found by the North Dakota station to be exceptionally rich in ascorbic acid, furnishing when ripe over 150 milligrams per 100 grams. Samples of jam made from the ripe buffaloberries contained from 80 to 90 milligrams per 100 grams. With as high a content as this even the small amounts of jam customarily used as a spread would make quite a contribution to the day's requirement of this vitamin.

New Hampshire-grown **blueberries,** according to preliminary tests by the New Hampshire station, contain enough ascorbic acid to make a fair contribution to the diet, at least to the extent that they are eaten in the fresh raw state. Samples of low-bush berries and two varieties of high-bush, the Rancocas and Rubel, furnished, respectively, 12.08, 13.36, and 11.69 milligrams per 100 grams.

Hawaiian-grown **papayas** are relatively high in ascorbic acid, according to reports from the Hawaii station. Samples of the Solo grown in two localities in Oahu ranged from about 60 to 122 milli-

grams and averaged between 80 and 90 milligrams per gram. **Mangoes** varied widely in ascorbic acid, the common Manini having the highest value, 114 milligrams per 100 grams, and the Haden and Palieri the lowest, 14 milligrams per 100 grams.

With few common foods outstandingly rich in thiamine, or the B vitamins in general, additions to the list of foods furnishing appreciable quantities are helpful in diet planning. More extensive use of **peanuts** because of the high quality of their protein will add to the thiamine content of the diet. Analysis by the Hawaii station of peanut butter from four commercial concerns in the United States gave thiamine values ranging from 0.324 to 0.450 milligram with an average of 0.380 milligram per 100 grams.

Two varieties of **pecans,** Halbert and Mahan, were tested by the Arizona station for thiamine and riboflavin and pronounced to be an excellent source of thiamine and a relatively poor source of riboflavin. The Mahan was higher in thiamine (0.944 milligram per 100 grams) than the Halbert (0.533 milligram per 100 grams). The relative value for riboflavin was reversed, the Mahan containing 0.063 and the Halbert 0.184 milligram per 100 grams.

Wild rice, harvested and parched for the market by the Indians of Minnesota, was found by the Minnesota station to be a good source of the several B vitamins tested, furnishing on an average 0.470 milligram per 100 grams of thiamine, 0.633 of riboflavin, 6.13 of nicotinic acid, and 1.01 milligrams per 100 grams of pantothenic acid.

Mushrooms of the commercially cultivated species, *Agaricus campestris*, as tested by the Massachusetts station, furnished 0.12 milligram of thiamine, 0.52 of riboflavin, 5.85 milligrams of nicotinic acid, and 2.38 milligrams of pantothenic acid per 100 grams.

The Oregon station is endeavoring to develop new sources of **fish oils** to supplement the high-vitamin oils formerly available, and is experimenting with species not commonly used for this purpose. Comparative studies of shark-, cod-, and other fish-liver oils have been made by the Florida station, which has found that the first-named offers splendid possibilities as a substitute for cod-liver oil. Since cod-liver oil is high in vitamin D and relatively low in vitamin A, the reverse of the condition found in shark-liver oil, the possible value of a combination of the two is at once apparent.

These few examples illustrate the contributions that are being made by the experiment stations in different parts of the country to a knowledge of the vitamin content of foods of local or regional interest or foods hitherto not receiving consideration as to their vitamin content.

ENRICHED FOODS

The enrichment of corn meal and grits.—The enactment by the South Carolina General Assembly in March 1943 of a law requiring the enrichment with thiamine, niacin, and iron of all degerminated corn meal and grits sold in the State was due in no small measure to actively prosecuted research by the South Carolina experiment station. A survey was made of the extent of consumption of various corn products and methods of cooking them in the State, and samples of the different products were analyzed for mineral and vitamin content. It was found that most of the grits consumed in the State were pearl or degerminated grits manufactured outside the State. Pearl grits and

degerminated corn were found to have a low vitamin and mineral content. The prevailing custom of washing grits before cooking precludes such means of enrichment as are used with flour, as the enriching ingredients would be lost in the rinsing water. To meet this difficulty, a premix was developed involving gelatinization of some ground grits, incorporation of the enriching ingredients, drying, and reduction to particles resembling grits in size and color. With this accomplished and a public service patent application filed on behalf of the college, the findings of the investigation were reviewed before the State Nutrition Committee which influenced the General Assembly to enact the law mentioned above. The results of the investigation are also being used through the National Research Council in the formulation of standards for proposed enrichment of corn products throughout the United States.

CONSERVATION OF NUTRITIVE VALUE OF FOODS

Mention has been made in the Introduction (p. 3) of the cooperative project under this title in which the experiment stations in 44 States are now participating. Because of the urgent need for reliable data in readily available form, the results of experiment station research on the vitamin content of foods for 1942 and the first half of 1943, including both independent and cooperative studies, have been evaluated and summarized in a Department Miscellaneous Publication,[2] to which the reader is referred for a more adequate review than can be given here. To illustrate the type of work being done under the National Cooperative Project two or three examples will be given, selected to show the different ways in which the various stations are contributing to the project.

THE SOUTHERN COOPERATIVE PLAN

For several years before the inauguration of the National Cooperative Project, horticulturists, home economists, and chemists in a number of the southern stations had been cooperating on an investigation of factors affecting the mineral composition of southern-grown vegetables. The first major phase of this project, a report of which is in press, involved growing turnip greens from the same seed source under several methods of fertilization, harvesting the material at as nearly as possible the same stage of maturity, and analyzing it for calcium, phosphorus, and nitrogen, identical procedures being followed by all the stations. The same general plan has been adopted by this group for their contributions to the National Cooperative Project. Turnip greens was the first food selected for a study of the effect on ascorbic acid content of variety—Shogoin and Seven Top; fertilizer—high and low levels of nitrogen; stage of growth—early, medium, and late; method of storage—room temperature and refrigerator; method of cooking—one-half hour and 4 hours; and season—spring and fall crops. Six stations participated in the project—the Georgia, Louisiana, Mississippi, Oklahoma, Virginia, and Virginia Truck stations. A preliminary report on the effect of storage and cooking was the first one of the series of mimeographed progress notes planned for prompt release of data on the National Cooperative Project. These progress

[2] U. S. Dept. Agr. Misc. Pub. No. 536. (In press.)

notes are sent to a limited number of the agencies most in need of such data for diet calculations, including the Offices of the Quartermaster General and Surgeon General of the United States Army and the Subsistence Branch of the United States Navy.

Because of the number of stations participating in the project more than 150 samples were available for the storage and cooking tests. Ascorbic acid losses averaged less than 5 percent when the greens were stored 24 hours at 40° F. and over 27 percent, or more than 5 times as much, when stored for the same length of time at room temperature. When the fresh greens were cooked for one-half hour the ascorbic acid losses averaged about 26 percent, and for 4 hours about 61 percent, or almost 3 times as much. The greens stored at room temperature, and already lower in ascorbic acid than the fresh greens, lost even more of this vitamin when cooked than did the fresh ones.

A preliminary progress note has been issued by the Georgia and North Carolina stations on the effect of curing, storage, and cooking on the carotene and ascorbic acid content of sweetpotatoes of the Louisiana Unit No. 1 strain of the Porto Rico variety. Butter beans and tomatoes are being similarly studied by three or more of the southern stations.

THE KEY STATE PLAN, WESTERN REGION

A key State plan has been adopted for the western region whereby each of the stations within the region is responsible for outlining needed research on a single food and planning for such research alone or in cooperation with other stations in the region. The plan may be illustrated by the work of the Colorado station on carrots. Work outlined by the station on this commodity has included the effect on certain nutrients of geographic and climatic conditions, variety, stage of growth, transportation under different conditions, marketing, trench and field storage, methods of handling, and methods of cooking and preservation. Other stations in the region, notably Arizona and New Mexico, are cooperating with the Colorado station in certain phases of the work. A recent phase of the work of the New Mexico station is a study of the losses of carotene and ascorbic acid in carrots as served to Army students quartered at the university.

Among the findings already announced by the Colorado station are the following: Mature carrots were greatly superior to baby carrots in carotene content. Mature carrots grown in 1942 and trench-stored until March 1943 were still in excellent condition and their carotene content equal or superior to that of small bunched carrots shipped in for the market. The trench-stored carrots yielded an excellent dehydrated product. Steam blanching was less destructive of nutrients than dip blanching in hot water, and under the best conditions from 70 to 100 percent of the carotene was conserved in the dehydrated product. The smaller the subdivision of carrot samples for dehydration the more rapid was the vitamin loss on subsequent storage. In the preparation of carrots for cooking, cleaning with a stiff brush conserved ascorbic acid during cooking to a greater extent than peeling. Holding carrots overnight in cold water did not cause significant losses in carotene, ascorbic acid, riboflavin, or niacin. Rapid steam cooking destroyed smaller amounts of carotene

and water-soluble vitamins than other cooking methods. Losses of water-soluble vitamins in boiled carrots were proportional to the quantities of water used in cooking.

The key State plan has more recently been adopted to some extent by the north-central and southern regions.

INDIVIDUAL STATION PROJECTS

Much of the research under the National Cooperative Project is conducted by the individual stations working entirely independently of other stations but following similar procedures in the preparation and analysis of the material tested. From a group of several mimeographed progress notes from the New York (Cornell) station, one will be used in illustration of studies of the effect of quantitative cookery procedures on vitamin content. This study dealt with the effect of quantity-cookery procedures with various proportions of water and material and different types of equipment, on the ascorbic acid, thiamine, and riboflavin retention in garden-fresh and fresh-market spinach. The spinach was cooked in 5-, 10-, 12-, and 30-pound lots. Obviously with such large amounts of material the number of factors possible of study and the number of repetitions of the same test were limited as compared with studies like the southern turnip-greens project in which small samples were used, but the conditions resemble more closely actual treatments such as are to be found in institution and Army and Navy mess cooking. Among the findings reported were that fresh-garden spinach contained considerably more ascorbic acid than fresh-market spinach shipped in from nearby points, and that spinach shipped in from Texas had a wide range in ascorbic acid content. The garden-fresh and the fresh-market spinach gave approximately the same values for thiamine and riboflavin.

During preliminary preparation for cooking (trimming, washing, and draining) which extended over 5 hours, there was about a 10-percent loss in ascorbic acid. Cooking in the different ways tested resulted in losses ranging from 33 to 69 percent; and holding the cooked spinach at a temperature of 150° F. (as on the steam table) resulted in further destruction, ranging from 17 percent for 15 minutes to 74 percent for 2 hours. Increasing the amount of spinach cooked in a given amount of water in a steam-jacketed kettle increased the retention of all three of the vitamins. Cooking the spinach in a steamer and in a steam-jacketed kettle gave about the same retention of ascorbic acid and of thiamine, but there was a slightly better retention of riboflavin in the steamer.

EVALUATION OF FOODS FOR GREATEST RETURNS

When choices must be made among foods, whether it be the vegetable crops to be grown by the large-scale market gardener or the home gardener, or foods to be purchased on a large scale, as for the Army mess or on a small scale for the home, or vegetables and fruits to be stored or preserved in the home for winter use, some bases of comparison which take into consideration all the factors involved are essential. Common to all of them in the present emergency is the relative nutritive value of different foods in terms of the essentials for

which the table of recommended daily allowances of the National Research Council serves as a practical measuring stick. For the grower, yield per acre and manpower required are also essential, for the food purchaser cost is an important factor, and for the home preserver the selection of methods giving the most attractive product with the least loss of nutrients.

NUTRITIVE INDEX FOR CROP PRODUCTION

Several divisions of the California station are cooperating in working out an adequate method for rating crops grown in California on the basis of greatest returns in human food in the present emergency. Evaluations are based on such factors as yield per acre of available product, values for the 9 nutrients included by the National Research Council in recommended allowances for adequate nutrition, and requirements as to man-hours, fertilizers, irrigation water, and packing the products. Of 26 vegetable crops thus rated, spinach, winter squash, potatoes, and cabbage ranked highest for yield per acre and per acre and man-hours combined. The suggestion has been made that if extreme economy of labor and equipment becomes necessary, vegetable crops ranking very low should be eliminated from production.

NUTRITIVE INDEX FOR FOOD PURCHASES

A wide range of foodstuffs is being studied by the New York (Cornell) station to determine their contribution of protein, calcium, iron, and six of the vitamins with relation to cost in ordinary servings as calculated from retail prices at frequent intervals.

Prices on over 60 items of food are collected every 2 weeks from 5 stores in Ithaca, and similar information from 5 cities of the State is being secured by following newspaper advertisements. It is hoped that the results of the study may provide information as to what foods at given times of the year will supply the largest quantity of nutrients at the lowest cost.

Nutritive indexes for fruits and vegetables have been developed by the California station to indicate the relative values of equal weights of different commodities as sources of the food essentials for which they are most valuable. The relative rankings thus obtained can be used by the small- or large-scale food purchaser or by the home gardener with limited space. In a grading of more than 20 vegetables in 11 classes on the basis of edible portion, green beans, broccoli, and lima beans ranked first and watermelons last, with summer squash, radishes, and cucumbers next to last.

HOUSEHOLD BUDGET FOR HOME PRESERVATION

A suggested budget was prepared by the Wyoming station for use by the homemaker in planning a fruit- and vegetable-preservation program to meet the nutritive needs of the family. For 19 vegetables grown in the State and 6 fruits obtained on the market information was assembled on the quantities of vitamin A, thiamine, vitamin C, riboflavin, calcium, and iron furnished by 100-gram portions, and suggestions made as to methods of preservation and number of times of serving during the year, and the amount to store or preserve per person.

FOOD REQUIREMENTS

The daily allowances for nine dietary essentials recommended by the Food and Nutrition Board of the National Research Council, and now used extensively as a nutrition yardstick (as noted in the previous section), were based upon critical examination of available data and are subject to change as new evidence is forthcoming. Data used in establishing allowances for protein, calcium, iron, vitamin A, thiamine, riboflavin, and ascorbic acid included contributions from the experiment stations, and continuing research at the stations is furnishing information which should be of value when the table is revised.

The experiment stations have been in a strategic position with respect to the availability of healthy young men and women of college age as experimental subjects. In the north-central region, advantage was taken of this about 7 years ago to organize a cooperative investigation among seven stations (Iowa, Kansas, Minnesota, Nebraska, Ohio, Oklahoma, and Wisconsin) on the nutritional status of college women. The number of subjects studied has been extensive enough to warrant placing considerable confidence in the data obtained as representative of healthy young women of comparable socioeconomic status. Of the nutrients included in the NRC-recommended allowances, calories, nitrogen, calcium, and iron and, more recently, ascorbic acid, have been studied by the north-central group. Ascorbic acid metabolism and requirements of college men and women have been studied cooperatively by five stations in the Northwest (Idaho, Montana, Oregon, Utah, and Washington) and more intensively over a considerable period of time at the New York (Cornell) station. College women served as subjects in an investigation of the requirements of vitamin A by the Rhode Island station. Children of preschool age have been studied by the New York (Cornell) station for ascorbic acid requirements and by the Michigan station for a number of nutrients.

CALORIES

The calorie intakes of 27 college women from two States (Kansas and Ohio) in the north-central cooperative investigation were determined by analyses of the food eaten over periods of different lengths during which the diets were freely chosen as to calories. The daily intakes by the same subjects varied considerably but not as much as did the intakes of different subjects. The mean intake for all the subjects was 35.7 calories per kilogram per day, representing about 2,000 calories for the average woman (56 kilograms). This value is considerably lower than the NRC allowance of 2,500 calories daily for a moderately active woman and 2,400 calories daily for girls 16 to 20 years of age.

CALCIUM

As part of the same north-central project, calcium, phosphorus, and nitrogen balances were obtained at the Iowa, Kansas, Ohio, and Nebraska stations for 124 college women on their customary diets, and at the first three places for 9 women on diets the calcium content of which was controlled by the use of 1, 2, or 3 cups of milk daily. For the total of 133 subjects ranging in age from 17 to 24 years, a mean daily intake of calcium of 0.8 gram was required for equilibrium.

With intakes less than this, only 43 percent of the subjects on self-chosen diets were able to store any calcium as compared with 70 percent of the small number on the controlled diet. From these findings it was considered that the NRC 1-gram calcium allowance for girls from 16 to 20 years of age might well be recommended for young women of the somewhat older age range of 17 to 24 years.

That women 20 to 24 years old should be classified with the 16- to 20-year-old girls rather than with mature women, in calcium allowance, is also suggested by the results obtained in another phase of this investigation. Anthropometric measurements taken on 209 subjects each year during the 4 years of their college attendance were sorted according to the age at entrance to college and analyzed for yearly changes. For each group there were significant increases in height during the 4 years, and, except for the group entering at 20 years, these increases were fairly regular during the successive years, showing that the subjects were still growing. In the calculations of the dietary needs of entire populations, it should be kept in mind that growth may continue beyond 20 years.

PROTEIN

The mean daily nitrogen intake required for equilibrium in the studies reported above for calcium was 9 grams, representing about 56 grams of protein. The value is close to the 60-gram NRC allowance of protein for women and considerably below the 75-gram allowance for girls of 16 to 20 years.

Studies by the Michigan station of the food requirements of children of preschool age have furnished considerable information on the protein needs of the age group as related to other factors. When the calories in the diet were increased by fat, sugars, or starch the children utilized a given amount of protein to better advantage, suggesting that if the protein content of the diet of children of this age group has to be reduced the calorie content must he high in order to keep the children in good physical condition.

VITAMIN A

Because of the storage of vitamin A in the body a long time is required to deplete the reserves of this vitamin to a point where the effect of measured doses on dark adaptation can be determined. The Rhode Island station developed a new portable dark-adaptation apparatus termed a "rhodometer," which was used to test over 300 college women and to determine the vitamin A requirement of a small number who volunteered to live on a vitamin A-free diet for many weeks. From tests on three subjects over a period of several months it was concluded that 5,500 I. U. of vitamin A daily was more than enough to maintain a satisfactory state of dark adaptation. This would indicate that for this small number of healthy women the NRC standard allowance of 5,000 I. U. was adequate.

ASCORBIC ACID (VITAMIN C)

Studies conducted by the New York (Cornell) station over a period of several years on the ascorbic acid metabolism of college men and women and of children of preschool age were given attention in the

formulation of the NRC allowances for these two age groups. In the studies of the preschool children 30 milligrams of ascorbic acid was found to be the amount required to maintain tissue saturation, orange juice giving somewhat better retention than an equivalent quantity of pure ascorbic acid. Corresponding values for the college men and women were in the neighborhood of 100 milligrams daily, with some variations on either side. The recommended NRC allowances are 50 milligrams daily for children 4 to 6 years old, 75 for men, and 70 for women, values somewhat higher for the children and lower for the adults than the Cornell figures.

In further work by the Cornell station, 4 young men and 1 young woman were maintained for 6 weeks on ascorbic acid intakes approximating the NRC allowances and then were given 400 milligrams of ascorbic acid daily to test their body supplies of this vitamin. The woman subject and 2 of the men required 2 doses and the other 2 men 3 and 4 doses to resaturate. Other tests suggested that even if the recommended allowances of ascorbic acid were insufficient for saturation an equilibrium was reached within a week or two. The ascorbic acid nutrition of college students as determined by the content of the vitamin in the blood plasma under standardized conditions was studied cooperatively at the Idaho, Montana, Oregon, Utah, and Washington stations on 471 women and 342 men students. Consistently lower values were found for the men than the women. This is thought to indicate either a higher vitamin C requirement by men or the need of more education in the wise choice of food, or both. That men are more apt than women to neglect good sources of vitamin C in selecting food may be inferred from the fact that the highest blood plasma ascorbic acid values for the women were found in the groups in cooperative houses where they did their own meal planning while the highest values for the boys were found in the groups living at home or in boarding houses. A higher requirement for men than for women is recognized in the NRC allowances.

DIETARY HABITS AND NUTRITIONAL STATUS

Increased knowledge of the nutritive value of foods both in the raw state and as finally consumed, of the nutritive requirements of various age groups, and of methods of evaluating nutritional status makes it possible to obtain a better idea of the adequacy of any diet than by simple calculations of food-consumption records. Complete studies in this field are time-consuming and expensive and very few have as yet been attempted at the land-grant institutions. Probably the most extensive studies to date are the Pennsylvania mass nutrition studies involving quantitative records of the food consumption, calculations of the nutritive value of the diets and comparisons of these with NRC allowances, and evaluation of the nutritional status of members of family groups and school populations.

Food-consumption records have been evaluated in a number of station studies by comparing quantities of the various foods with standard score cards or, more recently, by comparing the calculated nutrients in the diet with the NRC allowances, without in either case attempting to evaluate the nutritional status of the people consuming these diets. In some studies, certain nutrients have been given special

attention both in diet calculations and in nutritional status tests and in others special age groups have been considered.

FOOD CONSUMPTION AND NUTRITIONAL STATUS OF SCHOOL CHILDREN

The effect of a well-planned school lunch on the nutritional condition of elementary-school children was studied by the South Carolina station by comparing the diets and nutritional status with respect to hemoglobin, ascorbic acid, and vitamin A of the children of one school where a well-planned lunch was given daily with those of another school where the lunch was not planned and supervised. In the first school, diet scores for the day, including the home meals, were definitely higher, better gains in height were made during the year, and the hemoglobin values were maintained during the school year, while in the other school the values were lower at the end than at the beginning of the school year.

Tests for thiamine and ascorbic acid nutrition were conducted by the Arizona station on 67 Spanish-American children of low economic status and 41 American children of high economic status with results that at first glance might seem rather surprising. Only 10 percent of the first group gave satisfactory thiamine tests and none satisfactory ascorbic acid tests and less than 50 percent of the second group gave satisfactory tests for either vitamin. The customary diet of the Spanish-American group contains food of rather high thiamine content, such as dried beans and corn used in making frijoles, but the cooking methods commonly followed probably result in extensive losses of this vitamin. The low values of the American group were attributed to the extensive use of unenriched flour and cereals—a point in favor of the present universal enrichment of patent flour. The low values for C suggest the need for education in the use of the citrus fruits produced in the State.

Approximately one-third of 5,000 school children in Virginia were found by the Virginia station to be below accepted standards in a number of essential foods, such as milk, fruits, and green leafy and yellow vegetables. The rural children made a poorer showing than the urban and the Negro children than the white. It was thought that the poor diets of the average family were more closely related to faulty food habits and customs than to economic limitations.

An analysis of the food consumption, economic status, and nutritional condition of nearly 2,000 children in the Pennsylvania mass nutrition studies showed that some of the children in all the socioeconomic groups were below optimum in over-all nutritional status with the percentage of those showing undernutrition in the various aspects now observable or measurable increasing as incomes and family education increased.

These various studies with children emphasize the value of the school-lunch program and the various measures now being taken to spread nutrition education.

FOOD CONSUMPTION OF COLLEGE STUDENTS

To determine the adequacy of the diets of Ohio State University college men living in two residence halls with liberal and restricted food budgets, respectively, weekly food consumption records were studied in two ways—(1) the quantities of different food groups in nearly

300 records were computed and compared with commonly recommended amounts, and (2) the nutrients in 30 records from the first hall and 20 from the second were computed and compared with the standard allowances of the NRC. The first comparison showed that 93 percent of the entire group met the recommendations for milk; 66 percent for eggs, citrus fruits, and tomatoes, leafy, green, and yellow vegetables, and other fruits and vegetables; 50 percent for cereal products and sugar; 38 percent for fat; 25 percent for potatoes and for meat, fish, and poultry; and only 12 percent for legumes. Of the 30 records from the hall with liberal food budgets, one-half were adequate in all nutrients, as compared with only 2 out of the 20 from the hall with restricted food budgets. Protein, calcium, and iron met and exceeded the standards in all of the records. Total food consumption as represented by calories was below the standard in 23 percent of the first group and 55 percent of the second, and of the total vitamin deficiencies 58 and 74 percent were found in the records low in calories. Riboflavin and ascorbic acid deficiencies were found singly or in combination in 14 records from the first group and riboflavin alone or as a part of a multiple vitamin deficiency in 14 of the records of the second group. The evidence of inadequate riboflavin intake in terms of the NRC standards in spite of the fact that only 7 percent of the entire number in both halls were low in the consumption of milk, considered one of the best sources of riboflavin, points to the difficulty of meeting the riboflavin standards on ordinary diets.

A group of eight women students at the University of Nebraska lived for 6 months on a diet planned to include the quantities of different food groups suggested by the Bureau of Human Nutrition and Home Economics for a low-cost diet meeting the NRC-recommended food allowances. At monthly intervals these subjects, 12 others living under the same conditions but on self-chosen diets, and 8 others who were boarding were given certain nutritional status tests., The tests as far as completed showed no striking differences between the first group and the other two serving as controls, but the food accounts indicated that the first group had greater nutritive returns for the money spent and a greater intake of most of the dietary essentials.

PRODUCING NEEDED FIBERS, OILS, AND SPECIAL PRODUCTS

To aid replacement of essential agricultural products formerly imported and increase domestic production of other special crops according to need, the experiment stations are actively at work on problems involved in growing and utilizing plants that yield fibers, vegetable oils, starches, medicinals, and other products. A few of the recent accomplishments are presented as examples of a considerable volume of activities.

FIBER CROPS

Hard fibers for cordage, burlap, and special kinds of paper, in demand because supplies are no longer available from the Orient, have been extracted from native plants by the New Mexico station. *Yucca glauca* (soapweed), *Y. elata*, and nolina (sacahuiste) were found abundant enough in New Mexico to provide a commercial source of fiber to meet both civilian and military needs. The leaves

contained averages of 42.3, 43.0, and 48.5 percent, respectively, of crude fiber on an air-dry basis. Satisfactory fibers were obtained by retting or by pressure cooking supplemented by mechanical treatment. Yucca fibers were determined to be about as strong as hemp or Manila fibers and stronger than nolina fibers, which about equaled sisal, jute, and raw silk fiber. Heavy wrapping twine and three-fourths inch rope have been made commercially from fibers of *Y. glauca* furnished by the station, and an extraction plant has been in operation. A special hard-fiber paper being manufactured by a paper company from commercially harvested yucca has been meeting the requirements of the armed forces for this special paper. Nolina leaves appeared to be suitable for use in brooms, and samples are being tested by a manufacture.

Hemp is being grown in the Corn Belt as a war crop to meet emergency needs for strong fibers for marine rope, cordage, and thread. Commercial production in recent years had been limited largely to Wisconsin and Kentucky. In giving out practical instructions to farmers cooperating in the Government's hemp program, the Illinois and Iowa stations, for example, have drawn on the extensive findings of the Kentucky and Wisconsin stations and the Department, as well as on their own work with the crop. The need for labor saving in hemp production led the Iowa station to develop a machine requiring little power which turns the hemp in the swath for further retting. This machine can turn 2 acres per hour as compared with 3 acres per day by an experienced man. Power may be supplied by an ordinary farm truck.

A hempseed beater that saves both time and labor, designed by the Kentucky station, includes a trucklike body, with one open end into which the shocks are turned. Chains attached to a cylinder driven by a small gasoline engine beat out the seed, which is run through a combine thresher or fanning mill. Mounted on sled runners, the machine is pulled along the shock rows. An entire shock is handled at a time, the chains beating out the seed in less than 2 minutes. With it two men can beat out hempseed in half the time required in hand beating. The entire machine, with the exception of the gasoline engine, can be made on the farm at little cost.

All hempseed disinfected.—Seed supplies of hemp produced in 1942 were inadequate to plant the desired acreage in 1943. Necessity demanded that they be made to go as far as possible. Perhaps seed disinfection would help by insuring better germination, but this had never been tried on hempseed. Five State experiment stations volunteered to make quick winter greenhouse disinfection tests in cooperation with the Department. Identical representative lots of seed were distributed, treated, and planted. The average increase in emergence was 16 percent. The Government therefore arranged to have the Nation's total 1943 hempseed supply of over 200,000 bushels treated to give a measure of protection against seed- and soil-borne infection. Better germination resulted in the field, often more strikingly than in the preliminary tests. In fact, some growers were able to reduce the planting rate of the treated seed and had seed left over. This was fortunate, for the surplus was later used to replant acreages wiped out in the spring floods.

A one-row, one-mule planter and fertilizer-placement machine developed by the North Carolina station saves at least 4 man-hours per acre, requires one-third less power than with the usual practice, and increases yields through more effective placement. Use of the machine for cotton planting in the Coastal Plains area, it is estimated, would result in an increase of lint cotton of 45,000 bales and 22,700 tons of seed.

OIL CROPS

Peanuts for oil.—Farmers in Southern States were asked to greatly increase peanut production because of the need for vegetable oils, the large acreage of farm lands in the South suitable for the crop, and the capacity of southern oil mills to crush the additional tonnage. To attain the desired volume, production necessarily was extended into many areas not formerly growing peanuts commercially, and inexperienced growers were faced with many difficult problems and obstacles in production and disposal.

Peanut production in Mississippi, for example, had consisted largely of patches for family use. The Mississippi station helped by analyzing its research findings and the experiences of growers of Spanish peanuts in 1942, and thereby provided for potential growers of peanuts in 1943, timely information on cultural and harvest practices, on the place of the crop in the farm organization, and on comparative incomes from peanuts, cotton, and corn. Practices found productive and profitable include the choice of well-drained sandy soils broken or ridged well before planting; planting soaked Spanish peanuts in the hull at a rate of 60 pounds per acre, or shelled and dusted (with a disinfectant to prevent seed rot and damping-off) peanuts at a rate of 30 pounds per acre, about April 15 to May 15 in hills 6 inches apart in 24–30-inch rows; and cultivation with harrows to suppress grass and weeds and break the crust, and later with sweeps and shovels to work soil to the plants. Timely digging is very important. Digging with the turning plow or the middlebuster, with wings removed, should begin when most nuts are fully developed and the inside of the shell begins to color. The peanuts should be stacked around a 6–8-foot pole with cross bars, with the nuts in the center to prevent weathering. For most economical threshing and marketing, production should largely be concentrated within communities well adapted to peanuts. Furthermore, an orderly marketing program should be worked out so that producers can sell their peanuts without delay, and full-time buyers should be established in counties that produce 300 tons or more of nuts. Such solutions by the experiment stations of the peanut problems encountered in the South are definite contributions to the war effort.

Peanut dusting and seed treatment.—With more than 5,000,000 acres planted to peanuts in 1943 to meet war goals, disease-control practices that help maintain high production make possible more peanut oil for the Nation and better returns to the grower. North Carolina peanut growers who dusted their fields with 325-mesh sulfur according to the program developed by the North Carolina station got an average yield increase of 342 pounds of nuts per acre. Counting off $3.50 per acre for labor and materials, the net increase in income, at 7 cents per pound, was $30.24 per acre. Dusting also helped the

labor situation by making possible a 10-day delay in digging without loss. Work at a number of stations has established the value of seed treatment with Arasan, 2 percent Ceresan, and Spergon to improve stands, and of sulfur dust for leaf spot control. Dusting has quite consistently boosted yields of peanuts and hay 20 to 30 percent.

A new flax variety, Crystal, bred by the Minnesota station, was placed on the station's recommended list. The variety is moderately resistant to wilt; immune from rust; equal to Bison in seed size and oil content; and approaches Redwing in quality of oil.

Koto and Renew, brown-seeded flaxes of good height, ripening about the same time as Bison, developed by the North Dakota station and the Department, were under increase in 1943 in preparation for wider distribution. Koto is resistant to wilt and most prevailing races of rust; Renew is moderately resistant to wilt and highly resistant to rust. Victory, a productive new flax highly resistant to wilt and rust, was distributed in 1943. The breeding work has proceeded in close association with chemical studies, enabling the station to recommend to growers the flax varieties that will yield oil of superior drying qualities. These and other flax varieties released by the stations during the last few years will contribute greatly to meeting the increased demand for linseed oil.

Domestic supplies of castor-beans, source of the oil in great demand for war and industrial uses, continue to increase as results of the program in which the Department and a number of experiment stations are participating. Among station contributions are better varieties, effective cultural and harvest methods, and shelling machines, all largely aimed at minimizing hand labor, a costly item in the production of the crop.

K 38, a low-growing castor-bean with large clusters of burs, developed by the Kentucky station, has been easier to harvest than other varieties grown in comparison. It was one of the few varieties chosen by the Government for seed multiplication.

Conner has been the most productive castor-bean variety in Kansas and Kentucky station tests. The Kansas station experiments have produced useful information on dates of picking, oil contents of varieties, and harvest methods. Castor-beans, the station reports, have not responded to applications of phosphorus, nitrogen, or lime. The Illinois station published a practical circular, based on extensive experiments with the plant, on castor-beans as a war crop.

Shelling castor-bean seed from the capsules without injury to seed coats and consequent lowering of the quality of product has been a special problem solved in large measure by the use of practical shellers or threshers such as those developed by the Kentucky and Tennessee stations.

Safflower, a large thistlelike plant producing a drying oil valuable in industry, is very spiny and disagreeable to handle. The California station has developed an almost entirely spineless form which is now being increased for distribution to growers. Higher yield and quality of oil are other objectives nearing realization in the breeding program of the station.

STARCHES

New grain sorghums for starch as well as feed for livestock are aiding in meeting the wartime shortage of tapioca-type starch which

is in demand as a food and for industrial uses, besides giving Plains farmers a new cash crop.

Waxy Blackhull kafir, developed by the Texas station, was increased so that 50,000 pounds of seed were available for planting in 1943. The purity and quality of the starch in this new sorghum led a major food concern to contract for 25,000 acres to be grown in northwestern Texas. Reduction of labor needs and production costs by changing waxy endosperm (starch) characters into dwarf combine varieties is to be the outcome of current breeding work.

Cody (Waxy Club) sorghum, selected by the Kansas station and the Department from a cross between Leoti sorgo and Club sorghum, also has the desired waxy-type of endosperm. Resembling Club in most respects, being adapted to central and southern Kansas, Cody is resistant to pythium root rot (milo disease). A large food company has contracted for the total production from seed being increased under irrigation in Arizona, and other seed was being increased in Kansas to provide a seed supply for Kansas farmers for planting in 1944.

Leoti sorgo, a popular sorghum grown extensively in Nebraska, has a waxy endosperm and is also suitable for sirup. Its many-sided study of the problem enabled the Nebraska station to outline for farmers of the State appropriate cultural methods and harvest practices for the saving of the grain and efficient ways to use the forage. Appraisal of the current and future status of this crop is another definite wartime service to Nebraska farmers by the station.

MEDICINAL PLANTS

Aid toward an American source of quinine.—The importance of quinine obtained from the bark of the *Cinchona* tree has increased greatly since our armed forces have been actively engaged in tropical warfare. Because of urgent need for a source of quinine in the Western Hemisphere the Puerto Rico Federal station has concentrated work on increasing planting stock of *Cinchona* and the solution of cultural problems. Although the *Cinchona* plant is one of the most difficult to grow, investigations of the past year have resulted in the production of thousands of seedlings thriving under highly satisfactory conditions and the successful carrying of these seedlings through the nursery stage for permanent planting. Good soil drainage and adequate sunlight were found necessary to promote optimum growth. Analyses of samples of bark indicated the importance of including alkaloid content along with vigor and yield as one of the factors in selecting stock for propagation.

SPECIAL CROPS

Disease-resistant tobacco varieties.—New flue-cured tobacco varieties resistant to black root rot, a disease which seriously damages the crop in Piedmont areas of North Carolina, Virginia, and nearby tobacco sections, have been developed by the Virginia and North Carolina stations and the Department. Introduction of these varieties helps growers attain production goals and brings relief in the region where the disease may stunt growth and delay maturity to the extent that crop values may be reduced from 50 to 75 percent.

The 400 variety, selected by the North Carolina station and the Department from plants in Guilford County, N. C., is highly resistant to black root rot and slightly resistant to some of the leaf diseases, cures easily, and produces high yields of cigarette leaf, especially smoking leaf and lugs. Chemically, it has been as good as the better standard flue-cured varieties. The 400 variety is recommended for the Middle and Old Belts of North Carolina and Virginia.

The 401 variety, derived from a cross of 400 and Cash, also in North Carolina, has a favorable combination of characteristics of the parents in color, size, and body of leaf, together with partial resistance to root rot and apparently resistance to certain leaf-spot diseases. It has outyielded the standard flue-cured varieties, and the crop has a large percentage of lugs. The 401 appears suitable for culture throughout the flue-cured area.

Yellow Special, a new black root rot-resistant variety bred by the Virginia station, combines high yields, bright color, and fine leaf qualities, with some resistance also to black shank, sore shin, and damping-off. It is recommended for general use in the flue-cured belt of Virginia. Yellow Special will outyield by about 100 pounds per acre the root rot-susceptible varieties currently grown, according to tests and observations on Virginia farms. Several farmers reported returns from Yellow Special as high as $600 per acre in 1941 and $700 in 1942, about $100 per acre more than from other varieties on the same farms. Commercial tests showed that Yellow Special meets all requirements for a high-quality manufactured product.

Kentucky 52 Burley, a development of the Kentucky station, also resistant to black root rot and free from mosaic and exceptional in quality, was released in 1943. The root rot-resistant varieties bred earlier by the station have extensively replaced older susceptible varieties in important infested areas. Improvement has been evident also in the quality of the leaf produced by growers following the station recommendations. Practices resulting in more uniform and better-cured products have developed from test results, indicating the stage of maturity of both early and late crops for highest qualities and the devising of better ways for control of temperature and air movement in tobacco barns.

Tobacco mildew sprays.—With a million and a half acres to be planted to tobacco in 1943, downy mildew or blue mold attack in untreated seedbeds reduced field acreage and delayed planting from 2 to 4 weeks. Much of this loss can be avoided by the use of sprays developed by the stations and the Department. The Maryland station secured excellent blue mold control by early and repeated spraying with any of four recently developed fungicides, cuprous oxide with cottonseed oil, Fermate, bismuth subsalycilate, and Vatsol O. T. C. Fermate spray gave several Florida growers excellent results on large tobacco beds. This practice grew out of tests by the Florida station and the Connecticut (State) station which had shown the ability of Fermate to control the mildew with less difficulty and expense than the fumigants previously recommended.

Mucilage from guar seed.—Arizona station studies on the production of guar, *Cyamopsis psoralioides*, may provide southwestern farmers with a new cash crop as well as an excellent soil-improving crop. Grown in comparison with other summer green-manure crops,

guar gave better results than any other in subsequent yields of barley and was promising as a crop to precede winter vegetables. A second promising use is as a source of mucilage in the paper-making industry, to replace the carob bean normally obtained from the Mediterranean region. Tests with mucilage from guar seed by the Institute of Paper Chemistry have been so promising that an estimated 1,500 acres were planted in Arizona in 1943 for seed production. Station tests over several years indicate that guar sets seed and produces good yields under a variety of conditions. The seeds do not shatter appreciably and are readily harvested with a combine. Should guar be substituted entirely for the carob bean, an estimated 50,000 to 100,000 acres would be required to supply the needs of the paper industry alone, and other uses for the mucilage, as in the textile industry, are promising.

PROBLEMS OF ADJUSTMENT TO ABNORMAL WARTIME CONDITIONS

HELPING SET GOALS

As in former emergencies, the experiment stations have cooperated with each other and with the Department in the realization of agricultural production goals, both local and national. From the beginning of the emergency the stations have participated, and will continue to do so each year, in determining, allocating, and attaining the production goals of the foods and fibers required for both civilian and war needs. During the year all of the stations have collaborated with the Department in the study of maximum total production capacity of American agriculture, and in the study of adjustments in farm enterprises and crop and livestock systems essential to attain the end desired. Such adjustments are conditioned in part by the total need on the one hand, and on the other hand, by the availability of suitable lands, adapted crops and livestock, and such items as labor, fertilizer, fungicides and insecticides, and farm machinery. Studies dealing with these requirements have been made either independently or in collaboration with appropriate Federal agencies.

As an illustration of how all the State stations are helping solve the Nation's production problems, the New Mexico station assisted the Bureau of Agricultural Economics in estimating the State's wartime maximum agricultural capacity. The station also helped with an economic study to determine the feasibility of reclaiming more land in the Middle Rio Grande Conservancy District. Further, it furnished information to the BAE on the harvesting, transportation, and storing of the 1943 wheat crop, and provided data on the effect of ceiling prices of poultry and eggs on local production.

The Kansas station, in cooperation with the Department, prepared basic data needed in establishing production goals for 1944 and 1945 in Kansas. These studies drew upon the research that had been conducted at this station over the past 20 years or longer.

The Texas station made a study of maximum wartime production capacity in the State, in order to inventory the resources and appraise the capacity of these resources for producing food and other products of farms essential to the conduct of the war.

The Massachusetts station made a study to obtain data for use as a basis of judgment in operating wartime production and price programs, with special reference to livestock production.

The Idaho station estimated the amount of production possible with the lands, labor, and machinery likely to be available in 1944. These estimates will aid in the final establishment of the various production goals for different sections of the State.

At the request of the California USDA War Board, a study was made jointly by the California station and the Department, on California raisin-conservation experience in 1942 and its bearing on plans for 1943. The study presented facts and conclusions helpful to the State and county USDA War Boards, representatives of the California raisin industry, and Federal authorities in revising the raisin conservation order and planning for its administration in 1943.

After making a study based on classification of soils by slope and productivity, the Illinois station worked out suitable land use for 36 soil classes, along with calculated reasonable yields and acres of each crop by counties, and expected production of crops, livestock, and livestock-feed balance.

The Iowa station has developed an improved type of farm-sampling census in which 700 selected farms, representing all counties, were visited in January, April, July, October, and December. Information on the entire farm enterprise was secured each time. The collected data were then analyzed for particular types of information needed in connection with war production planning and policy making. Representative facts have been gathered with speed and accuracy. The survey indicated a 16-percent increase in hogs, which proved to be correct. This plan was also used to determine the extent to which the acreage of intertilled crops, such as corn and soybeans, could be expanded without increasing soil erosion. Preliminary analysis indicated that the total intertilled acreage might be increased to 12.1 million acres or to 13.7 million if the land needing it is contoured. In contrast, the 1940 intertilled acreage was only 10.7 million acres. Proper land use requires an increase in acreage in certain parts of the State and a decrease in others. The farm sampling census showed the need for more adequate storage and processing capacity for soybeans in connection with the war production program. Information was secured on the availability of and need for different kinds of farm machinery.

HELPING REACH GOALS

In the Nation-wide effort to obtain maximum production for war purposes, farmers and stockmen were confronted with problems of how to shift from less essential to the more essential products, crop and livestock adaptations considered. To help producers make these shifts, the State stations synthesized new and accumulated data for type-of-farming regions, showing how these shifts might be made to greatest advantage and with least loss of time and effort. Of outstanding value among these studies were a number made in the Southern States, both published and unpublished, which helped to bring about an increase in the production of peanuts and soybeans for their proteins and fats.

At the request of farm leaders, a survey of prospective changes in acreages of crops and numbers of livestock in California in 1943 as compared with 1942 was undertaken by the California station in December 1942. Opinions as to the 1943 outlook were obtained for 52 crop and 10 livestock enterprises. Information was furnished farmers on the prospective supply of production factors such as spray mate-

rials, sacks, box shook, baling wire, fertilizer, feeds, seeds, and farm labor.

A study was made by the Missouri station of the nature of current rural problems and the extent of participation of the farm population in State and National programs, the factors involved, and the history and trends of rural community life so that current changes might be better understood and forthcoming changes anticipated. The data were analyzed and the findings made available.

Information obtained from the New Mexico station project on range organization and management practices has been influential in adjusting livestock numbers down to the grazing capacities of ranges. During the period of high war prices data on trends and intentions of ranchmen have been valuable in setting up goals.

An emergency study of the expected feed requirements of Missouri made by the Missouri station in the spring of 1943 revealed a probable need of 100 million bushels of corn, 50 million bushels of oats, and large tonnages of both roughage and protein concentrates above the amounts likely to be produced within the State. This information is being used to assist farmers in planning pasture and feed-crop production and adjustments in livestock numbers during the current season.

The Iowa station studied the factors retarding maximum production on Iowa farms. The relation of these factors to the success of various Government production goals provided guidance in connection with future production programs. A thorough study of the neighborhood-leader system in five counties brought out facts which resulted in greater effectiveness. Research on the effect of a fixed price ceiling on the livestock and meat situation led to the adoption of policies designed to avoid concentration of hog marketing in the peak months of December and January. Studies of the operation of consumer rationing and price-control programs, both in this country and in England, disclosed that the point rationing system is probably the best method to be used in respect to most foods in this country. The favorable and unfavorable effects of various types of control of prices and supplies were important disclosures. The station has also conducted studies on national agricultural policies and programs, resulting in a series of memoranda and printed pamphlets helpful in State and National wartime planning.

The California station studied the requirements for shelters and houses for farm workers. Designs were prepared and plans drawn for structures of various sizes and types needed for comfortable housing, including a tent-cabin, bunk houses, a family dwelling, a bathhouse and laundry. Detailed structural plans and lists of materials were arranged for convenient distribution to farmers and ranchers who wish to provide improved housing for hired workers.

To aid in the realization of maximum production goals, the Utah station made a study of the marketing of fruits and vegetables, including their production and distribution and factors influencing them. The data gathered will be valuable both in realizing the 1944 goals and in the post-war period.

THE FARM LABOR SITUATION

To effect the adjustments in labor requirements made necessary by the drain of men for the armed forces and for war industries, many

of the stations analyzed the regular and seasonal labor requirements for crop and livestock enterprises of different kinds and the available manpower in the rural districts. Such data have facilitated the matter of adjusting the labor supply to the immediate demands in the all-out production effort. These studies, designed to throw light on the farm-labor requirements, have been conducted in cooperation with agencies concerned, at both State and National levels.

The Pennsylvania station found that with a 20-percent shortage in farm labor there was a reduction of 7 percent in numbers of cows milked and a decrease of 3 percent in animal units. Compensating for this shift from livestock was an increase of 16 percent in laying hens in 1941–42. The shift, principally from dairying, was toward the production of meat animals in general and more intensive crop production.

In a study of labor requirements for war food and fiber production, the Washington station found that production was affected most by the availability and proper use of farm labor and machinery. The information gathered indicated the localities where labor was most needed and the types of machinery that should be brought in.

An analysis of desirable types of organization at the farm and in the community in order to make the most effective use of victory workers during the 1943 season was made by the California station. The recommendations are based upon an extensive survey of experience by farmers, Y. M. C. A. groups, schools, and others during the 1942 season. Stress was placed on steps to be taken by individual farmers to determine their needs in advance and for planning tasks and supervising workers. Concrete suggestions were offered for a number of community committees to survey housing facilities and to provide for organized recreation for victory workers.

The Louisiana station made a study of farm-labor needs and requirements by months, seasons, and by type-of-farming areas, and of the farm labor available, by kind, season, and area. Information needed for growing and harvesting the essential war crops and livestock products was furnished to cooperating State and Federal agencies.

The Washington station showed that about one-half of the commercially producing farms of Washington lost workers who were engaged regularly on those farms in 1942, and that only one-fourth of the lost workers were replaced. Nearly half of the lost workers went into the armed forces. In 1942, there were substantial losses of hay due to shortage of workers. Estimates of the number of man-hours required in raising various important crops were compiled for a number of counties of the State. These data are of considerable value in helping to determine the number of farm workers needed.

That farm labor might be employed with greatest effectiveness, the Florida station determined, through motion and time studies, more effective methods of performing specific operations, such as the tying of tomatoes to stakes, with resulting efficiency in the production, harvesting, and marketing of the fruit and vegetable crops of the State.

Data on number of persons employed in citrus packing were obtained by the California station. These data were analyzed with a view to determining the extent, if any, to which a given volume of fruit could be handled with a smaller number of total workers by exchange of employees between packing houses.

As an aid to wartime agricultural production in the State, the Kentucky station completed a study in the spring of 1943 which showed the need for labor and its availability in crop and livestock production in the eastern part of the State. It was found that about 35 percent of the heads of families were potentially available for employment elsewhere, while 30 percent were classified as not able to work elsewhere and the remaining 35 percent were already productively employed.

The amount of labor required to meet 1943 war goals was calculated by specialists of the Utah station. Data were broken down into labor requirements by counties, by months, and by the various crops and types of livestock. These figures enable various planning agencies to meet peak labor requirements by bringing farm labor to the counties needing it.

In special studies of labor efficiency, the New York (Cornell) station brought together all available information from the departments of agricultural economics, pomology, plant pathology, and entomology, and reworked it from the standpoint of increasing the efficiency of spraying trees on fruit farms. Several procedures have already been determined, whereby more gallons per day can be applied with less labor and at lower cost, while at the same time making most effective use of the amounts of spray materials available. A similar study was made with the object of increasing the efficiency of labor on dairy farms.

As an aid to the attainment of agricultural production goals, the Ohio station cooperated with the Farm Security Administration in moving a group of farm workers from a surplus labor area in eastern Kentucky to Ohio farms and training them. Study of their skills, interests, and aptitudes or other characteristics led to the development of criteria for adjusting such laborers to new environments and this enhanced both the supply and the efficiency of farm labor in the State.

In a study by the Vermont station, by timing the usual operations involved in feeding, milking, removing manure, etc., and by making changes in the arrangements of stalls and types of equipment, the workers were able to reduce the time spent on chores by 36 percent and the distance walked by 58 percent.

In a study by the Maryland station, the hours of man labor per acre required were found to be as follows: Corn for grain, 50.3; corn for silage, 40.9; wheat, 11.4; barley, 10.4; winter oats, 6.9; spring oats, 14.1; rye, 10.1; mixed hay, 7.9; alfalfa hay, 20.7; soybeans for hay, 16.9; soybeans for grain, 7.9; early potatoes, 73.5; late potatoes, 98.4; and sweet corn, 30.6. Comparison of records of farms using the greatest amount of labor with those using the least amount of labor showed the importance of using labor-saving machinery and organizing the work to produce more with less input of labor.

A bulletin of the New Mexico station, dealing with labor needs for seasonal operations on New Mexico farms, brought together especially timely and valuable information showing areas of critical labor needs, critical operations and dates, and estimates of number of workers needed by periods in critical areas. Suggestions were given for reducing labor requirements and for securing more workers.

The Kansas station prepared labor-requirement data for every important crop and every important type of livestock in Kansas on the basis of type-of-farming areas, and the data were broken down into

the labor requirements by months of the year. From these data it is possible to compute total labor requirements for crops and livestock in the State and relate these requirements to the available and potential labor supply. This information has been helpful in obtaining additional labor for use in critical periods, and it serves as a guide to those in charge of recruiting and placing additional labor on Kansas farms.

Data on total and seasonal labor requirements, together with equipment requirements, were collected by the Florida station in a general farming area of north and west Florida, for 11 crops. Records were also collected for livestock, labor, feed, and material requirements for hogs, cattle, horses, mules, and chickens. The data were being used in estimating seasonal labor needs of interest to governmental agencies dealing with the farm labor problem. Extension and other agricultural workers have also used the data in estimating income opportunities and adjusting crop acreages to meet war production goals.

A survey worked out by the Iowa station indicated that substantial increases in war production of essential foods like pork and poultry and dairy products would be possible by better use of underused manpower existing in relatively high degree on the smaller farms.

Information on machinery available on farms and on its age and expected life obtained by the Arizona station from interviews with 348 farmers in the three major irrigated farming counties of Arizona has been useful in administering the machinery rationing program. The calculations of machinery rental rates have been particularly valuable to farmers interested in renting as an alternative to the custom machinery work formerly available but now difficult to get because of labor shortages.

In a survey of available farm labor of an urban center, the North Carolina station found that in Washington, N. C., out of 2,380 Negroes 10 or more years of age, 1,480, or 62 percent, had some farm experience; and 1,220, or 51 percent, were available for farm work. Some 1,200, or 50 percent, with farm experience were not working on farms; 440, or 18 percent, had worked on farms the previous year but were not working on farms at the time the study was made; 810, or 34 percent, were not then employed at any paying job; 500, or 21 percent, more people were available for farm work than had actually worked on farms the previous year; and 260, or 11 percent, fewer people were available for farm work than had had farm experience.

MARKETING AND TRANSPORTATION

Excessive demands upon the railroads of the country for part-time transportation, together with the shortage of trucks, tires, and gasoline for cross-country transportation, called for immediate studies leading to drastic economies in transportation facilities as a whole. Some examples of the type of emergency study that the stations made of marketing and transportation follow:

The Ohio station investigated current shifts in milk supply within milksheds of the State. This study involved the extent of turn-over of milk producers in given market areas, what producers are going out of production and to what extent they are being replaced, the locations of shippers dropping out and of new shippers, and the reasons for producers dropping out of milk production.

In a preliminary study of the suitability of paper and cotton bags as a substitute for potato containers, the California station found that sound potatoes carried well in 50-lb. paper bags. The relatively high humidity in these bags promoted the development of new skin, but caused some increase in decay. Cotton fabric bags increased shrinkage and caused bag marking in transit. Bags made of cotton sheeting proved desirable but not so strong as burlap, and potatoes appeared more subject to greening in them than in burlap.

Studies by the Connecticut (Storrs) station of the operations of 100 milk dealers revealed that alternate-day delivery had reduced delivery mileage an average of 44 percent with proportionate savings in gasoline, oil, tires, and equipment. With adequate home refrigeration the increased storage period caused no serious deterioration provided the milk was of good quality. Results were used by the State Milk Administrator.

Analyses of data by the Connecticut (Storrs) station showed that savings of approximately 35 percent in mileage, equipment, and manpower would be possible through a reorganization of country assembly and reallocation of milk supplies to the principal markets. Results were used by the State Dairy Conservation Committee and the U. S. Food Distribution Administration.

A survey of livestock-trucking practices made by the Indiana station led to the formulation of plans for reducing pick-up mileage and for incurring full loads for each trip to market. Similarly, practical means were developed for conserving motortrucks by reducing mileage travel in collecting farm milk, cream, eggs, and poultry. Improvement of delivery of tomatoes to canneries and prevention of glut at the cannery also resulted from this study.

The Minnesota Station in a study of deliveries of petroleum products to farmers found that economies might be effected by delivery of more gallons of gasoline per mile of travel by truck. While the average delivery was 15 gallons per mile of travel, one driver sold 43 gallons per mile of truck travel. Again, the average truck delivered but 54 percent of the load the driver started out with.

The Iowa station made a study of cream routes and developed information helpful to State and Federal authorities in working out transportation problems of the dairy industry. A study of the purchase by and delivery of petroleum to farmers was also made. Analysis showed a possible saving of approximately one-third the present mileage through elimination of duplicate routes. The results have been of great use to agencies dealing with wartime consumption of gasoline, oil, tires, and trucks, with conservation of transportation, and with competitive wastes.

Emergency studies by the Kentucky station of the wartime situation regarding prices of farm products and the factors controlling them, and extensive surveys, at different seasons, of the systems used in transporting farm products to markets helped farmers with their marketing problems and laid the basis for conserving truck transportation, the chief means of getting farm produce to market in that State.

In a study of the transportation and storage of potatoes, the Maine station made estimates of the essential requirements, including tires and gasoline, for hauling. A study of possible savings in milk delivery resulted in every-other-day delivery, which proved satisfactory to consumers.

At the request of the USDA War Board and FDA and in cooperation with FDA, AAA, State Milk Control Board, State Department of Agriculture, and State Extension Service, the Maine station made a detailed survey of milk-collection routes which revealed much duplication in travel. The results were used for the reorganization of routes to save gasoline, tires, and labor.

Studies conducted by the Missouri station included the in-and-out-movement of farm commodities in representative counties, farm-to-market transportation problems among milk producers in the St. Louis milkshed, and livestock transportation problems in different counties. On the basis of the findings, consolidation of truck mileage was accomplished.

The New Hampshire station mapped milk-collection routes for the State and showed much overlapping with possibilities of savings in mileage and concurrent use of tires, gasoline, etc. In the Colbrook area, the ODT put into operation a plan of milk collection based on the study, with a saving of 330 miles of travel each day.

A State-wide survey of farm trucks completed by the Oregon station showed that the addition of not less than 1,000 new trucks a year during the war is essential to maintain adequate transportation for moving farm products to market.

Data collected by the Vermont station on truck routes and loadings throughout the State led to recommendations for constructive changes that would conserve tires and gasoline and would make possible the collection of milk with considerably less equipment than currently used.

From a survey of the fishing industry, the Puerto Rico University station found that the equipment used was inadequate for catching enough fish to form an important part of Puerto Rican dietary. The boats were too small and without refrigeration or icing facilities. The results reported were used by the Insular Emergency Council of the Puerto Rico Planning Board when appraising plans for the rehabilitation of the industry. The Insular Government will finance the purchase of improved fishing equipment.

A study made of milk routes by the Rhode Island station led to the discovery of much overlapping and wasted mileage. Alternate-day deliveries were found entirely satisfactory if good-quality milk were supplied and if the home owner had adequate refrigeration.

A survey was made by the Illinois station of the trucking of milk in Bloomington, Rockford, and St. Louis areas; livestock trucking in Chicago, East St. Louis, Springfield, and three smaller markets; truck hauling of farm products, both farm and commercial, in Douglas and Henderson Counties; and trucking of vegetables in Chicago and fruit in southern and western Illinois. Plans were drawn for avoiding duplication of routes, thus greatly reducing mileage in all fields. Factual data were made available as to actual conditions of trucks and tires, calling attention to difficulties that may be encountered before the end of 1943. Truck replacement is likely to become more acute than tire shortage.

Early in 1942 the Wisconsin station in cooperation with the State Department of Agriculture made a careful survey of milk assembling in Wisconsin. Out of this study and conferences of Federal and

State agencies concerned with transportation grew a State-wide program for mileage reduction for milk-assembling trucks.

A study of transportation of milk by the West Virginia station showed that the efficiency of the assembling of milk could be increased 30 percent by consolidation of routes and getting farmers who haul their own milk to patronize new or established routes. It was estimated that probably a further saving of 25 percent in mileage is possible.

COSTS AND PRICES

Emergency studies of costs and prices by many of the stations have been helpful in the adjustment of prices to costs necessary to expedite maximum production for war purposes.

In a survey of the cost of producing hogs, the Puerto Rico University station found that the cost per hundredweight of gain averaged $9.73. The expense for feed averaged 38 percent of the total cost; labor, 27 percent; the use of hogyards and pigsties, 16 percent; and interest on inventory, 15 percent. The other expenses were relatively unimportant. Total receipts averaged $16.58 per hundredweight of gain, leaving a profit of $6.85.

In a comparative study of the cost of producing flax and wheat, the North Dakota station found that there is a tendency to grow flax on farms of medium to large acreages and that farmers are inclined to grow flax when its price is double or more that of wheat. The average gross income per acre for flax over a 10-year period was equal to that of hard red spring wheat. Growers using better cultural practices profited relatively more from flax.

A study by the Florida station included analyses of factors influencing the cost of production of citrus fruits which enabled Florida growers to compare the costs and returns with the average of all cooperators having citrus trees of a similar kind and age and thus modify their practices to obtain the greatest possible net return.

Cost studies conducted in five areas of the State by the New York (Cornell) station on about 100 farms per area showed that the average cost of milk production ranged from $2.37 to $1.87 per hundredweight and the average annual total labor income was $700 and $298 in the best and poorest area, respectively. Seasonal variations in cost of production were lowest in areas near the New York City market and greatest in the remote areas.

Records by the New York (Cornell) station from 120 commercial poultry farms in New York showed that returns per man-hour of labor from the entire poultry business, with flocks averaging 1,192 layers per farm, were 61 cents for farms with light breeds and 53 cents for those with heavy or general-purpose breeds.

A continued study of farm land values has been conducted by the Iowa station to obtain indications of inflationary trends. This research aims to lay a basis for forecasting the approach and make it possible for the proper authorities to start in time to check speculation in farms, as experienced in connection with the first World War.

A study of prices of farm products by the Florida station enabled producers to determine what crops and livestock to emphasize within production goals, time of year to produce them, within limits, and when to sell, except in the case of perishable products. These data were of value also in both the determination and the allocation of crop production goals each year.

A canning-crop survey conducted by the New York (Cornell) station provided information used as a basis for determining the prices necessary to ensure the production of the volume of canning crops needed for the armed forces, Lend-Lease, and civilian consumption. Cost-of-production studies on milk enabled the State and Federal agencies to deal more intelligently with this critical problem. General cost-account studies on all important New York farm crops have aided in many ways. They were especially useful in recent months in connection with the marketing of cabbage and beans. The emphasis in research on prices was being shifted constantly to meet emergency problems as they arose.

To furnish information for price supports and price ceilings the Florida station developed and computed a price index of Florida farm prices which included 37 products. Price indexes computed for a single State give a better basis for comparison between commodities or with prices paid than does the index for the whole United States.

The monthly expenditures for beef, pork, dairy products, poultry products, potatoes, bread, and flour by a typical workingman's family in Minnesota in 1935–39 and January 1943 were as follows: In the period 1935–39 the amount spent was $20.50 and in January 1943, $26.22, an increase of 28 percent. Of the total expenditures for the items mentioned, the farmer received $9.76 in the period 1935–39, or 48 percent, while the processor and distributor received $10.74, or 52 percent; whereas in January 1943, $15.84, or 60 percent, was received by the farmer, and $10.38, or 40 percent, by the processor and distributor. In this connection it is of interest to note that the index of cash farm income in the State in 1942 was 222 compared with an index of 100 for the best period, 1935–39. This increased income was due to an index of physical volume of 157 and an index of prices of 143. These figures, obtained through research of the Minnesota station, throw light on the farmers' parity position.

The California station helped prepare a report for the use of the California USDA War Board in making recommendations to OPA concerning policy and methods for determining maximum prices on fresh fruit and vegetables. Preparation of this report involved a study of the methods employed in Canada on fixing selling prices on potatoes. The methods employed were simplified by eliminating farm and shipping-point price ceilings and fixing only wholesale and retail prices in consuming markets.

Approximately 8 percent of the milk produced in Maine is sold as farm butter. Information was presented by the Maine station which resulted in agreement by the OPA that the point value of farm butter should be reduced to 5 points on petition of farm-butter sellers for a 30-day period, subject to renewal.

In a study of farmers' cooperative associations, the Florida station found that the most important factors determining the success or failure of citrus marketing cooperatives are prices received for fruit, cost of packing, and volume of fruit handled. Volume affects cooperatives' costs and prices, both of which affect the prices paid growers.

Wyoming station studies, over the years, of costs and returns to the sheep industry of the State have been assembled at the request of Government agencies to provide a scientific basis for establishing freight rates on sheep and wool and to supply information on expected returns from ceiling prices on wool.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

PERSONNEL AND PUBLICATIONS

The personnel figures in table 1 are based on data from the publication Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, 1942–43. This list was compiled from information furnished by the stations in the early fall and the numbers therefore represent the situation near the beginning rather than at the close of the fiscal year 1943. The numbers of station staff members do not include temporary employees, such as graduate assistants, fellows, etc., and staff members who were on leave of absence for service with the armed forces. The total research workers in 1943 is shown as 4,780, including 2,276 full-time workers and 2,504 workers who divided time between research and teaching or extension work. As compared with the figures for 1942, this was a reduction of 147 total workers and 128 full-time workers.

The publications of the stations in 1943 include 1,130 bulletins, circulars, and reports, 2,137 articles in scientific journals, and 740 miscellaneous publications. In 1942 the comparable figures were 975, 2,157, and 670. A considerable number of special articles and reports issued by the stations in processed form are not included in these figures.

INCOME

The total income of the experiment stations for 1943 was $24,203,873.56 as compared with $22,664,840.99 in 1942. This included $6,926,207.08 of Federal-grant funds and $17,277,666.48 of non-Federal funds, or approximately $1 of Federal to $2.49 of non-Federal funds.

Federal-grant funds.—The total of $6,926,207.08 of Federal-grant funds available to the States, Alaska, Hawaii, and Puerto Rico in 1943 was the same as for the fiscal year 1942. Each State received $90,000 under the Hatch, Adams, and Purnell Acts, and Alaska received $25,000, Hawaii $67,500, and Puerto Rico $50,000. The total under these authorizations was $4,462,500. The $2,463,707.08 appropriated under title I of the Bankhead-Jones Act was allotted to the States, Alaska, Hawaii, and Puerto Rico on the basis of rural population, with a special proviso that no State should receive less funds because of changes revealed by the 1940 census.

Non-Federal funds.—The total income of the stations from non-Federal sources, including State appropriations, research grants, fellowships, and receipts from fees, sales, and miscellaneous sources, of $17,277,666.48 in 1943 compares with $15,738,633.91 in 1942, an increase of $1,539,032.57.

The 1943 income under the various funds is shown by States in table 2 and the totals of Federal-grant funds disbursed through 1943 to each State, Alaska, Hawaii, and Puerto Rico are shown in table 8.

EXPENDITURES

Classified expenditures for each station under the Hatch Act are shown in table 3, the Adams Act in table 4, the Purnell Act in table 5, the Bankhead-Jones Act in table 6, and for non-Federal funds in table 7.

TABLE I.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1943*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications					
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications	
			Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Pages*	*Number*	*Pages*	*Number*	*Pages*
Alabama	Feb. 27, 1889	Apr. 1, 1888	37	32	1	1	71	6	141	21	161	25	126
Alaska	May 2, 1929	May 1, 1931	5	1	1		7	1	42				
Arizona	Mar. 19, 1889	July 1, 1889	25	34			59	12	484	15	116	15	93
Arkansas	Mar. 7, 1889	Apr. 2, 1888	27	38	2	2	69	17	820	19	127		
California	Mar. 12, 1889	Mar. 13, 1888	95	209			304	28	1,812	241	1,712	364	5,313
Colorado	Mar. 25, 1889	Feb. 20, 1888	24	42		2	68	17	443	10	69	68	317
Connecticut:													
State	May 18, 1887	May 18, 1887	56				56	18	662	19	197	15	19
Storrs	do	Apr. 1, 1888	24	17	2	3	46	9	407	20	134		
Delaware	Apr. 14, 1887	Feb. 21, 1888	7	14	3	3	27	5	182				
Florida	June 7, 1887	Mar. 16, 1888	74	14	4	5	97	44	757	45	243	44	65
Georgia	Dec. 24, 1888	Feb. 18, 1888	39				39	19	625	13	72	1	20
Hawaii	Mar. 31, 1911	July 1, 1929	25	11			36	8	476	6	63		
Idaho	Jan. 23, 1891	Feb. 26, 1892	13	28	2	5	48	9	181				
Illinois	May 11, 1887	Mar. 21, 1888	56	88	4	7	155	9	380				
Indiana	Jan. 19, 1889	July 1, 1887	108	39	5	2	154	25	804				
Iowa	Mar. 1, 1888	Feb. 17, 1888	88	137	33	7	265	44	2,482	93	1,186		
Kansas	Mar. 3, 1887	Feb. 8, 1888	35	94	1		130	22	878	53	53		
Kentucky	Feb. 20, 1888	Apr. 29, 1888	62	23	2	6	93	26	814	51	254		
Louisiana	July 12, 1888	Apr. 5, 1887	60	34		1	95	24	680	19	84	32	259
Maine	Mar. 16, 1887	Feb. 16, 1888	34	7			41	13	1,077	4	30	4	45
Maryland	Mar. 6, 1888	Mar. 9, 1888	16	31	4	19	70	13	475	31	31	8	16
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	66	17			83	28	658	34	186		
Michigan	Apr. 12, 1889	Feb. 26, 1888	56	105	6	7	174	27	1,347	58	454		
Minnesota	Feb. 4, 1889	Jan. 26, 1888	48	114	4	3	169	18	807	89	178	20	60
Mississippi	Jan. 31, 1888	Spring 1888	36	23		2	61	39	905	12	60		
Missouri	June 11, 1889	Jan. 31, 1888	15	81	1	2	99	78	1,767	54	54		
Montana	Feb. 16, 1893	July 1, 1893	26	20	1	10	57	23	618	8	62	2	63
Nebraska	Mar. 31, 1887	June 14, 1887	32	27	2		61	16	451	31	31		
Nevada	Feb. 8, 1889	Dec. 1887	19	2			21	5	148				

New Hampshire	Aug. 4, 1887	Feb. 22, 1888	8	42		6	56	18	464				
New Jersey: College / State	Mar. 16, 1887	Mar. 5, 1888	54	57	2	1	114	74	1,008	82	82		
New Mexico	Feb. 28, 1889	Nov. 14, 1889	8	22	1	1	32	37	506	4	20	3	4
New York: Cornell	Mar. 30, 1887	Apr. 30, 1888	25	141	6	20	192	21	901	424	2,285		
State	(1)		81				81	28	611	48	48	8	16
North Carolina	Mar. 7, 1887	Dec. 5, 1889	58	39	3	9	109	18	472	26	104		
North Dakota	Mar. 8, 1890	Oct. 15, 1890	27	25		2	54	19	445	42	141	3	13
Ohio	Mar. 16, 1887	Apr. 2, 1888	124				124	25	822	67	67		
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	34	64	1		99	39	890	46	228		
Oregon	Feb. 25, 1889	July 2, 1888	56	52	2	5	115	49	433	42	42		
Pennsylvania	June 3, 1887	June 30, 1887		156		1	157	17	554	46	307	20	307
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	57				57	13	449				
Rhode Island	Mar. 31, 1887	Nov. 3, 1881	19	7		6	32	7	368	8	50	4	39
South Carolina	Dec. 22, 1887	Jan. 1888	56	23	3	1	83	10	525	4	35		
South Dakota	Mar. 11, 1887	Nov. 17, 1887	9	37		2	48	17	550	8	28		
Tennessee	Mar. 29, 1887	July 24, 1887	59	18			77	9	223				
Texas	Apr. 2, 1887	Jan. 25, 1888	157	2			159	19	998	37	216	63	170
Utah	Mar. 8, 1888	Nov. 16, 1889	23	39	1	6	69	12	322	23	142		
Vermont	Nov. 1888	Feb. 28, 1888	18	14	2	2	36	17	583				
Virginia	Feb. 29, 1888	June 13, 1888	38	10	1	5	54	24	553	26	125		
Washington	Mar. 9, 1891	May 1, 1891	69	38			107	30	903	21	120	34	140
West Virginia	Feb. 22, 1889	June 11, 1888	24	37	3	8	72	3	147	16	124	3	78
Wisconsin	Session of 1887	July 1, 1887	47	82	8	18	155	9	383	220	440	2	10
Wyoming	Jan. 10, 1891	Mar. 27, 1891	17	26			43	12	415	1	12	2	11
Total			2,276	2,213	111	180	4,780	1,130	34,848	2,137	10,173	740	7,184

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.

TABLE 2.—*Income of the experiment stations for the year ended June 30, 1943*

Station	Federal grants [1]			Non-Federal							Grand total
	Hatch, Adams, and Purnell [2]	Bankhead-Jones	Total	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total	
Alabama	$90,000	$82,695.12	$172,695.12	$162,300.00	$13,176.48		$149,887.57		$282,465.77	$607,829.82	$780,524.94
Alaska	25,000	2,252.44	27,252.44	7,500.00			23,321.95		84.12	30,906.07	58,158.51
Arizona	90,000	13,285.16	103,285.16	96,756.40			46,974.15			143,730.55	247,015.71
Arkansas	90,000	63,983.20	153,983.20	144,891.34			63,805.61		18,819.25	227,516.20	381,499.40
California	90,000	81,893.64	171,893.64	1,065,289.92	121,474.95		101,886.08		81,683.17	1,370,334.12	1,542,227.76
Colorado	90,000	22,430.96	112,430.96	107,908.17	3,272.00	$320.70	41,685.82		83,718.53	236,905.22	349,336.18
Connecticut:											
State	45,000	11,253.66	56,253.66	139,403.95	13,061.14					152,465.09	208,718.75
Storrs	45,000	11,253.66	56,253.66	71,295.00	20,490.31					91,785.31	148,038.97
Delaware	90,000	5,189.96	95,189.96	31,802.53	6,328.01		43,050.38		7,863.58	89,044.50	184,234.46
Florida	90,000	34,782.16	124,782.16	538,909.51			133,001.38		147,550.24	819,461.13	944,243.29
Georgia	90,000	87,522.92	177,522.92	40,260.00	23,464.15		44,844.69		15,681.26	124,250.10	301,773.02
Hawaii	67,500	9,186.40	76,686.40	107,083.46	3,230.52		34,183.97			144,497.95	221,184.35
Idaho	90,000	14,219.84	104,219.84	37,665.29	680.00		46,501.54			84,846.83	189,066.67
Illinois	90,000	86,736.52	176,736.52	424,515.91	26,301.47		110,457.12			561,274.50	738,011.02
Indiana	90,000	62,900.44	152,900.44	326,328.07	40,209.08	26,368.19	253,492.65	$11,344.74	215,547.09	873,289.82	1,026,190.26
Iowa	90,000	64,854.64	154,854.64	253,550.00	66,336.59		48,131.94	73,070.63	56,537.61	497,626.77	652,481.41
Kansas	90,000	50,050.96	140,050.96	139,429.76		134,026.30		2,560.00	22,186.44	298,202.50	438,253.46
Kentucky	90,000	81,533.32	171,533.32	99,500.00		178,431.20	60,369.59	22,176.69	70,660.97	431,138.45	602,671.77
Louisiana	90,000	56,502.80	146,502.80	210,484.41	29,625.81					240,110.22	386,613.02
Maine	90,000	20,692.16	110,692.16	72,543.53	300.00		24,102.16	12,286.87	4,545.56	113,778.12	224,470.28
Maryland	90,000	30,259.72	120,259.72	88,161.56	6,224.34		68,292.66		47,329.36	210,007.92	330,267.64
Massachusetts	90,000	18,674.92	108,674.92	139,220.55	7,685.26					146,905.81	255,580.73
Michigan	90,000	73,566.60	163,566.60	237,235.66			39,184.75			276,420.41	439,987.01
Minnesota	90,000	57,269.04	147,269.04	326,050.17	29,140.45	2,475.74	95,255.02	4,490.12		457,411.50	604,680.54
Mississippi	90,000	72,651.40	162,651.40	129,669.01	11,208.96		127,662.92	12,497.64	80,391.76	361,430.29	524,081.69
Missouri	90,000	76,967.80	166,967.80	93,290.40	23,003.52	24,394.65	51,800.37		53,903.08	246,392.02	413,359.82
Montana	90,000	15,503.16	105,503.16	96,699.00			94,929.06		29,253.53	220,881.59	326,384.75
Nebraska	90,000	38,776.60	128,776.60	120,714.70			108,689.32			229,404.02	358,180.62
Nevada	90,000	2,734.64	92,734.64	4,739.64			16,357.80		5,313.37	26,410.81	119,145.45

New Hampshire	90,000	8,507.40	98,507.40	9,922.44			8,477.22		8,580.16	26,979.82	125,487.22
New Jersey	90,000	31,260.32	121,260.32	438,284.80	123,807.47					562,092.27	683,352.59
New Mexico	90,000	14,516.00	104,516.00	26,114.40			31,864.29		48,991.10	106,969.79	211,485.79
New York:											
Cornell	81,000	85,030.40	166,030.40	703,218.44		29,242.71	87,728.13	2,849.43		823,038.71	989,069.11
State	9,000	9,447.84	18,447.84	373,751.25			14,718.51			388,469.76	406,917.60
North Carolina	90,000	106,085.56	196,085.56	143,590.15			33,484.20	15,670.78	8,683.36	201,428.49	397,514.05
North Dakota	90,000	24,675.76	114,675.76	69,816.15	1,567.60		45,150.39	516.60	1,621.21	118,671.95	233,347.71
Ohio	90,000	93,717.64	183,717.64	714,406.00			171,927.25	23,495.79	572,198.15	1,482,027.19	1,665,744.83
Oklahoma	90,000	68,450.84	158,450.84	159,003.37	4,119.50	59,618.52	115,722.68	6,039.02	30,624.07	375,127.16	533,578.00
Oregon	90,000	22,790.32	112,790.32	229,689.55	7,522.83	77,993.72	66,824.34			382,030.44	494,820.76
Pennsylvania	90,000	135,322.64	225,322.64	146,572.59	39,888.51		58,853.43		9,532.27	254,846.80	480,169.44
Puerto Rico	50,000	53,213.24	103,213.24	201,418.39			9,061.11			210,479.50	313,692.74
Rhode Island	90,000	2,449.04	92,449.04	3,500.00			11,387.06		1,668.46	16,555.52	109,004.56
South Carolina	90,000	59,464.96	149,464.96	112,158.55			196,256.52		20,370.55	328,785.62	478,250.58
South Dakota	90,000	24,432.44	114,432.44	27,760.00	4,288.73		50,779.30		21,725.91	104,553.94	218,986.38
Tennessee	90,000	77,136.04	167,136.04	43,540.91			82,812.96			126,353.87	293,489.91
Texas	90,000	149,364.76	239,364.76	424,386.40	10,664.50		488,355.02	43,411.32		966,817.24	1,206,182.00
Utah	90,000	10,503.68	100,503.68	52,702.00	2,870.00		22,027.89		8,358.75	85,958.64	186,462.32
Vermont	90,000	10,471.60	100,471.60			10,186.07				10,186.07	110,657.67
Virginia	90,000	71,144.56	161,144.56	125,390.00			20,599.89	480.00		146,469.89	307,614.45
Washington	90,000	33,254.64	123,254.64	212,778.75	3,815.24		75,827.98			292,421.97	415,676.61
West Virginia	90,000	55,859.16	145,859.16	73,445.25			68,762.18		31,292.75	173,500.18	319,359.34
Wisconsin	90,000	60,224.88	150,224.88	343,785.00	184,570.00		139,085.00			667,440.00	817,664.88
Wyoming	90,000	6,759.52	96,759.52	21,556.02			49,029.18		41,613.82	112,204.02	208,963.54
Total	4,462,500	2,463,707.08	6,926,207.08	9,969,988.35	828,327.42	543,057.80	3,676,603.03	230,889.63	2,028,800.25	17,277,666.48	24,203,873.56

[1] Includes unexpended balances from the previous year as follows:
Hatch—Connecticut Storrs, $0.30; Illinois, $0.79; Oklahoma, $8.46; Rhode Island, $60.69.
Adams—Delaware, $92.85; Hawaii, $419.56; Puerto Rico, $10.25; Vermont, $401.64.
Purnell—Delaware, $824.74; Puerto Rico, $2,177.36; Rhode Island, $293.68.
Bankhead-Jones—Connecticut Storrs, $2.15; Puerto Rico, $211.36.

[2] Hatch, $15,000 for each State Alaska, Hawaii, and Puerto Rico.
Adams, $15,000 for each State, Hawaii, and Puerto Rico; $7,500 for Alaska.
Purnell, $60,000 for each State; $2,500 for Alaska; $37,500 for Hawaii;, and $20,000 for Puerto Rico.

TABLE 3.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)*[1] *for the year ended June 30, 1943*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$13,037.14	$4.50	$86.59	$203.83	$90.48	$21.00	$108.47	$942.86	$475.12	$30.01		$15,000.00		$15,000
Alaska	10,714.45	207.16	286.44		109.24		394.36	2,827.81	460.54			15,000.00		15,000
Arizona	14,108.29	197.31		51.97		366.00	47.40	184.43	44.60			15,000.00		15,000
Arkansas	9,037.25	493.54	9.32	133.88	27.65	2,078.62	113.69	2,435.96	473.49		$196.60	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	14,792.04										207.96	15,000.00		15,000
Connecticut:														
State	7,500.00											7,500.00		7,500
Storrs	3,339.20	191.89	.55	128.77		15.30		2,170.22	1,004.61			6,850.54	$649.46	7,500
Delaware	9,742.68	428.00	17.23	1,109.16	40.33	1,410.53	36.80	993.24	1,097.44			14,875.41	124.59	15,000
Florida	15,000.00											15,000.00		15,000
Georgia	11,871.85	425.03		2.71		1,276.11	151.70	861.40	411.20			15,000.00		15,000
Hawaii	14,641.25							358.75				15,000.00		15,000
Idaho	7,526.60	1,056.15	97.96	1,090.21	4.37	1,305.29	178.90	2,768.35	949.36	22.81		15,000.00		15,000
Illinois	13,668.90										401.55	14,070.45	929.55	15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	14,227.78	457.92		16.30	9.00	62.76		221.36	4.88			15,000.00		15,000
Kentucky	14,047.32					952.68						15,000.00		15,000
Louisiana	12,622.55	332.77	1.56	25.88		1,022.81	145.21	449.22	400.00			15,000.00		15,000
Maine	10,154.35	664.58	105.99	539.74	811.16	1,070.42	30.45	1,348.04	275.27			15,000.00		15,000
Maryland	12,486.66	279.70	42.36	46.65	4.50		117.48	1,787.47	204.38	30.80		15,000.00		15,000
Massachusetts	12,188.24	250.92				2,557.84	3.00					15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	12,478.32	421.44	18.23					1,579.96	168.36		333.69	15,000.00		15,000
Mississippi	11,131.97	768.99	26.52	342.10	170.41	1,351.57	127.81	982.45	98.18			15,000.00		15,000
Missouri	14,553.73										446.27	15,000.00		15,000
Montana	9,748.67	278.33	15.57	545.99	623.82	1,787.12	218.21	1,575.06	207.23			15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	11,783.56	74.35	103.00	367.92	310.33	205.64	40.10	1,917.75	197.35			15,000.00		15,000

New Hampshire	9,649.10	461.16	353.51	464.65	700.00	418.12	140.56	494.37	1,714.30	604.23		15,000.00		15,000
New Jersey	12,958.35	98.55		50.85		819.32	186.90	266.37	619.66			15,000.00		15,000
New Mexico	12,619.43	246.19	12.28	3.00	258.72	1,045.28	32.75	553.81	228.54			15,000.00		15,000
New York:														
Cornell	10,822.60	15.25		32.48			105.22	1,554.22	970.23			13,500.00		13,500
State	1,148.53							51.47	300.00			1,500.00		1,500
North Carolina	12,340.00	940.29	14.92	235.44		1,363.79	10.70	79.06	15.80			15,000.00		15,000
North Dakota	12,960.82			101.63	105.08	515.49	51.86	498.57	766.55			15,000.00		15,000
Ohio	10,085.31	492.12	43.29	319.36	317.18		316.53	2,447.81	978.40			15,000.00		15,000
Oklahoma	9,157.22	937.02	7.49	7.10		87.28	79.45	3,314.03	1,410.41			15,000.00		15,000
Oregon	11,745.13	437.85		53.94	398.95	814.89	155.38	1,316.51	77.35			15,000.00		15,000
Pennsylvania	11,586.89		.40			3,064.43	14.92	176.15	157.21			15,000.00		15,000
Puerto Rico	9,538.83	300.64		213.37		500.35	221.00	2,113.85	1,988.04			14,876.08	123.92	15,000
Rhode Island	10,233.93	266.52	9.43	194.55	250.28	568.68	121.80	2,519.69	686.93			14,851.81	148.19	15,000
South Carolina	11,228.60	26.07	12.58	445.92	107.27	1,063.08	27.35	994.67	1,006.34		88.12	15,000.00		15,000
South Dakota	10,709.21	392.97	13.20	98.39	11.00	779.81	106.61	1,885.14	1,003.67			15,000.00		15,000
Tennessee	10,975.56	73.03	95.57	519.80	21.14	1,540.09	232.33	740.11	789.77	12.60		15,000.00		15,000
Texas	12,927.89	497.00		195.55			52.25	1,006.36	20.95	300.00		15,000.00		15,000
Utah	11,606.22	178.78	1.17	16.90		2.20	11.40	2,702.85	417.37	63.11		15,000.00		15,000
Vermont	6,192.78	58.30	21.96	557.96	2,929.25	2,680.21	366.31	808.23	457.14			14,072.14	927.86	15,000
Virginia	13,229.07	77.15		44.10	176.09	101.25	54.70	1,120.94	196.70			15,000.00		15,000
Washington	12,564.36	781.87	7.63	11.46	40.00	815.13	52.81	179.97	166.27		380.28	14,999.78	.22	15,000
West Virginia	12,574.22	73.26	115.62		5.00	826.77	168.18	1,172.26	64.69			15,000.00		15,000
Wisconsin	12,846.90	918.50	3.25	5.00	15.16	168.21	51.32	991.66				15,000.00		15,000
Wyoming	11,027.50	272.45	54.26	33.00	390.48	570.94	316.40	2,002.15	332.82			15,000.00		15,000
Total	616,131.25	14,077.55	1,577.88	8,209.56	7,926.89	33,229.01	4,590.31	52,394.58	20,841.15	1,063.56	2,054.47	762,096.21	2,903.79	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 4.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)[1] for the year ended June 30, 1943*

Station	Expenditures											Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$11,300.54	$200.35	$48.15	$20.90	$612.65	$109.74	$1,403.03	$730.25	$13.60		$14,439.21	$560.79	$15,000
Alaska	7,029.77		86.13				384.10				7,500.00		7,500
Arizona	11,671.34	1,557.25	15.17	63.97	243.51	60.88	1,073.35	314.53			15,000.00		15,000
Arkansas	12,621.45	133.54	17.57	17.28	223.48	17.35	1,175.51	268.25		$525.57	15,000.00		15,000
California	15,000.00										15,000.00		15,000
Colorado	13,295.39	297.76		.17	256.48	75.23	170.74	321.75		582.48	15,000.00		15,000
Connecticut:													
State	7,500.00										7,500.00		7,500
Storrs	7,500.00										7,500.00		7,500
Delaware	12,116.83	433.71	71.55	.45	139.87	18.47	1,059.15	239.81			14,079.84	920.16	15,000
Florida	14,034.20			9.36		6.00	305.46	644.98			15,000.00		15,000
Georgia	11,022.65		77.39	2.93			3,614.56	282.47			15,000.00		15,000
Hawaii	12,154.99		15.64	.20		46.30	971.31				13,188.44	1,811.56	15,000
Idaho	14,020.15	112.00	9.36		15.00	24.96	714.23	104.30			15,000.00		15,000
Illinois	14,573.82									423.50	14,997.32	2.68	15,000
Indiana	14,460.66			18.32		36.50	415.47	69.05			15,000.00		15,000
Iowa	15,000.00										15,000.00		15,000
Kansas	13,144.72		16.48			38.23	1,493.90	306.67			15,000.00		15,000
Kentucky	14,117.63		11.86			11.34	790.85	68.32			15,000.00		15,000
Louisiana	13,195.21	289.55	2.73	3.32		43.95	961.40	503.84			15,000.00		15,000
Maine	13,820.81	104.41	12.83	.30	145.20	34.92	839.44	42.09			15,000.00		15,000
Maryland	11,606.63		1.61	39.92		99.46	1,645.81	953.97	652.60		15,000.00		15,000
Massachusetts	15,000.00										15,000.00		15,000
Michigan	15,000.00										15,000.00		15,000
Minnesota	13,782.89		3.00		90.00		624.88	137.44		361.79	15,000.00		15,000
Mississippi	11,762.85	10.91	43.14	32.58	342.54	511.68	1,124.03	1,172.27			15,000.00		15,000
Missouri	10,118.36		28.10		21.00	84.32	3,518.59	993.41	80.00	156.22	15,000.00		15,000
Montana	13,225.47	582.02	2.08	.85		7.30	434.96	747.32			15,000.00		15,000
Nebraska	15,000.00										15,000.00		15,000
Nevada	12,924.05	250.97	25.61	81.30		55.00	1,407.37	255.70			15,000.00		15,000

New Hampshire	13,244.58	164.65	21.09	7.60		42.89	691.73	823.22	4.24		15,000.00		15,000
New Jersey	12,394.82	26.78				35.23	1,924.87	618.30			15,000.00		15,000
New Mexico	12,763.12	245.52	54.51	8.00	432.90	120.92	950.88	424.15			15,000.00		15,000
New York:													
Cornell	11,046.54					11.47	1,909.04	365.14			13,332.19	167.81	13,500
State	1,500.00										1,500.00		1,500
North Carolina	12,787.29	299.16	22.61	37.93		37.35	664.10	1,151.56			15,000.00		15,000
North Dakota	13,125.16		2.49			33.33	611.96	1,211.08			14,984.02	15.98	15,000
Ohio	9,543.53	1.96	18.24			5.50	1,890.24	47.19			11,506.66	3,493.34	15,000
Oklahoma	9,760.87	13.58	3.35			256.72	3,674.92	1,290.56			15,000.00		15,000
Oregon	12,981.15	384.33	1.80	7.79	29.45	10.95	1,278.66	292.79	13.08		15,000.00		15,000
Pennsylvania	15,000.00										15,000.00		15,000
Puerto Rico	11,699.07	31.00	15.00		78.61		1,378.35	1,460.92			14,662.95	337.05	15,000
Rhode Island	13,650.91	48.61			17.48	236.61	968.85				14,922.46	77.54	15,000
South Carolina	12,345.90	104.10		107.00	276.02	105.69	1,347.13	139.71	450.00	124.45	15,000.00		15,000
South Dakota	12,133.11	539.23	100.59	13.51		44.52	1,040.15	1,050.39	78.50		15,000.00		15,000
Tennessee	13,082.93		15.84	5.43	6.84	76.81	1,658.36	153.79			15,000.00		15,000
Texas	14,958.50			1.50			40.00				15,000.00		15,000
Utah	13,047.91	588.97	5.16			47.38	1,024.60	255.29	30.69		15,000.00		15,000
Vermont	9,015.81	50.35	19.58	4.00		237.18	859.97	326.38	649.33		11,162.60	3,837.40	15,000
Virginia	12,520.08	152.81	47.25		15.25	43.33	2,170.07	51.21			15,000.00		15,000
Washington	13,545.51	165.00				1.32	571.05	314.62		402.50	15,000.00		15,000
West Virginia	13,300.00	59.94	6.71			47.54	1,197.47	388.34			15,000.00		15,000
Wisconsin	14,579.00						421.00				15,000.00		15,000
Wyoming	11,757.45	433.94	42.49	31.88		12.83	2,172.25	549.16			15,000.00		15,000
Total	655,783.65	7,282.40	865.11	516.49	2,946.28	2,689.20	52,573.79	19,070.22	1,972.04	2,576.51	746,275.69	11,224.31	757,500

[1] Extended to Hawaii by act of May 16, 1928; to Puerto Rico by act of Mar. 4, 1931; and to Alaska by act of June 30, 1936.

TABLE 5.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)[1] for the year ended June 30, 1943*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$47,502.57	$1,070.29	$243.30	$185.03	$1,508.31	$431.05	$290.88	$7,202.46	$1,469.30			$59,903.19	$96.81	$60,000
Alaska	1,166.34		703.37					630.29				2,500.00		2,500
Arizona	46,445.30	1,915.31	206.16	86.11	640.62	1,029.78	285.24	7,534.38	1,857.10			60,000.00		60,000
Arkansas	49,461.25	711.82	20.15	103.13	1,122.04	1,346.88	254.30	4,039.13	1,500.10		$989.46	59,548.26	451.74	60,000
California	60,000.00											60,000.00		60,000
Colorado	49,722.37	1,815.18	31.29	64.03	1,000.97	829.51	512.02	3,698.82	1,368.97		956.84	60,000.00		60,000
Connecticut:														
State	24,972.78	158.26	12.53		38.86	75.24	349.51	1,904.31	860.14	$1,030.00		29,401.63	598.37	30,000
Storrs	24,263.74	320.30	.58	195.70		45.72	134.31	2,334.04	1,382.46			28,676.85	1,323.15	30,000
Delaware	44,694.99	2,712.14	30.60	4.54	755.65	1,520.47	527.82	5,049.99	1,744.44			57,040.64	2,959.36	60,000
Florida	51,078.30	2,428.55	69.90	26.40	437.29		45.24	3,721.35	2,192.97			60,000.00		60,000
Georgia	45,893.97	1,141.19	145.25	1.80		1,775.63	1,105.45	8,047.35	1,889.36			60,000.00		60,000
Hawaii	33,695.35	205.79					416.91	1,160.29	2,021.66			37,500.00		37,500
Idaho	51,440.60	1,728.42	12.10	93.06	278.00	271.47	353.31	4,881.55	941.49			60,000.00		60,000
Illinois	47,916.70	1,027.21	15.41	87.02	60.00	1,936.75	971.50	3,043.09	517.19		746.68	56,321.55	3,678.45	60,000
Indiana	54,072.09	1,934.78	3.93	96.73	4.00		381.49	2,891.85	615.13			60,000.00		60,000
Iowa	59,845.10					125.00			29.90			60,000.00		60,000
Kansas	55,191.38	279.46	2.56		219.00	69.59	227.79	2,469.47	1,140.75	400.00		60,000.00		60,000
Kentucky	52,411.50	2,777.09	13.09	247.91	11.20	1,440.72	427.15	629.53	2,041.81			60,000.00		60,000
Louisiana	49,309.46	2,753.19	118.43	37.85	23.70	380.26	707.26	4,551.67	2,033.87	84.31		60,000.00		60,000
Maine	48,053.66	1,148.91	63.35	5.36	1,208.00	1,717.86	337,22	5,942.68	1,522.96			60,000.00		60,000
Maryland	45,806.49	1,682.53	61.40	141.34	151.13	2,185.09	149.37	6,018.88	3,803.77			60,000.00		60,000
Massachusetts	54,197.27	679.82				450.61	91.50	1,762.36	2,177.61			59,359.17	640.83	60,000
Michigan	50,946.13	223.22	3.71	.13		1,530.43	250.95	2,983.73	3,258.29			59,196.59	803.41	60,000
Minnesota	51,020.33	919.27	80.02	68.26	206.74	806.98	235.41	4,421.52	1,433.26		808.21	60,000.00		60,000
Mississippi	41,425.67	2,197.85	298.06	731.30	1,270.89	1,037.53	1,511.77	9,029.71	2,334.20	163.02		60,000.00		60,000
Missouri	42,540.72	1,729.07	233.21	132.47	364.03	1,673.24	713.99	11,278.57	809.51	27.49	497.70	60,000.00		60,000
Montana	50,125.66	1,235.35	26.88	51.08	677.47	2,062.01	119.94	4,907.46	794.15			60,000.00		60,000
Nebraska	48,860.28	540.30	36.26	106.43	15.00	1,275.59	439.12	6,312.67	2,414.35			60,000.00		60,000
Nevada	48,637.04	979.32	93.96	565.96	362.44	599.60	712.08	6,688.69	1,337.43	23.48		60,000.00		60,000

New Hampshire	47,906.18	1,089.38	94.95	38.00	385.27	852.61	126.98	4,297.12	1,822.76	3,386.75		60,000.00		60,000
New Jersey	53,019.16	838.44	.99	48.75	121.00	44.60	427.67	4,070.68	1,186.21	242.50		60,000.00		60,000
New Mexico	44,904.39	1,059.26	128.81	165.17	1,381.40	1,300.91	717.17	9,053.51	1,213.68	75.70		60,000.00		60,000
New York:														
Cornell	45,148.85	369.93	.35	88.45	2,330.80	359.00	791.77	2,932.82	1,436.50			53,458.47	541.53	54,000
State	5,813.74	7.92			93.44			60.74	24.16			6,000.00		6,000
North Carolina	48,402.31	2,343.99	8.13	260.65	720.00	316.67	729.84	5,307.50	1,910.91			60,000.00		60,000
North Dakota	46,679.91	632.37	2.07	278.11	195.84	892.82	828.31	7,069.06	3,178.51	243.00		60,000.00		60,000
Ohio	47,610.77	527.64	1.05		13.17	230.03	51.35	2,546.83	1,312.74			52,893.58	7,106.42	60,000
Oklahoma	40,751.67	813.93	23.71	32.17	70.30	827.91	1,100.87	9,302.95	2,280.61	4,795.88		60,000.00		60,000
Oregon	46,247.48	2,219.86	170.99	597.30	100.42	1,136.40	2,403.98	4,500.30	2,539.95	83.32		60,000.00		60,000
Pennsylvania	49,867.60	785.94	8.36	88.80	1,084.22		306.53	7,259.31	565.81	33.43		60,000.00		60,000
Puerto Rico	15,752.17	2,032.12				831.24		271.71	166.00			19,053.24	946.76	20,000
Rhode Island	47,807.96	279.79			332.42	1,756.86	138.84	7,952.45	657.49	285.75		59,211.56	788.44	60,000
South Carolina	44,455.97	271.44	209.70	684.97	490.52	852.02	1,978.28	9,451.28	1,197.18		408.64	60,000.00		60,000
South Dakota	46,589.32	1,612.15	117.19	199.31	48.80	2,047.80	305.90	5,808.20	3,260.46	10.87		60,000.00		60,000
Tennessee	54,642.89	505.29	84.11	19.36	172.80	390.40	346.95	3,110.93	727.27			60,000.00		60,000
Texas	52,696.36	917.23	36.69	291.99	12.39		322.57	3,610.87	2,006.90	105.00		60,000.00		60,000
Utah	51,237.30	2,490.72	83.11	16.50	354.00	854.10	520.29	3,357.26	1,086.72			60,000.00		60,000
Vermont	49,900.37	1,668.71	33.14	63.00	56.39	6.06	1,125.16	5,019.40	586.05	340.28		58,798.56	1,201.44	60,000
Virginia	50,918.65	438.07	.35	257.91	722.21	1,658.05	1,068.84	3,458.96	936.78		519.77	59,979.59	20.41	60,000
Washington	48,466.94	1,648.42	2.40	126.74	48.00	3,768.24	241.46	4,333.90	614.95		748.95	60,000.00		60,000
West Virginia	50,081.60	1,124.46	129.75		794.11	1,182.91	552.39	5,508.34	626.44			60,000.00		60,000
Wisconsin	56,091.46	262.07	.62		15.00	533.42	22.00	3,075.43				60,000.00		60,000
Wyoming	46,147.66	1,259.58	53.05	4.71	37.50	789.76	290.57	9,741.56	1,675.61			60,000.00		60,000
Total	2,421,837.75	59,513.33	3,715.02	6,293.53	20,535.34	45,248.82	25,949.25	244,236.95	74,505.86	11,330.78	5,676.25	2,918,842.88	21,157.12	2,940,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 6.—*Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935) for the year ended June 30, 1943*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$59,901.21	$1,370.54	$373.00	$261.89	$1,152.42	$900.45	$578.84	$12,660.40	$3,341.11	$2,155.26		$82,695.12		$82,695.12
Alaska	1,090.81		23.90					1,137.73				2,252.44		2,252.44
Arizona	9,241.82	790.73	11.40	163.37	250.30	670.40	376.12	560.07	1,220.95			13,285.16		13,285.16
Arkansas	44,423.07	1,759.54	125.32	86.97	1,242.65	3,614.31	449.36	7,127.73	4,334.97	44.97	$774.31	63,983.20		63,983.20
California	81,893.64											81,893.64		81,893.64
Colorado	15,697.00	577.04	1.80	52.54	643.15	265.78	552.30	3,561.16	785.40		294.79	22,430.96		22,430.96
Connecticut:														
State	9,064.17				85.00	12.60	41.55	823.01	510.03	717.30		11,253.66		11,253.66
Storrs	7,877.13					77.18	1.95	1,607.94	698.00			10,262.20	$991.46	11,253.66
Delaware	3,669.92	28.88				21.50	4.50	901.53	45.01	460.00		5,131.34	58.62	5,189.96
Florida	25,450.80	1,041.50	39.46	3.53	196.50		457.51	4,206.21	1,324.43	2,062.22		34,782.16		34,782.16
Georgia	51,554.49	1,676.65	563.75	1.91	375.00	957.49	1,083.92	27,478.02	1,427.36	2,404.33		87,522.92		87,522.92
Hawaii	6,464.69							2,721.71				9,186.40		9,186.40
Idaho	8,632.15	691.61		1.11	240.00	17.30	328.96	3,959.70	349.01			14,219.84		14,219.84
Illinois	57,924.70	1,910.72	436.49	56.41	169.03	208.12	3,360.58	7,404.31	8,833.11	182.52	1,229.50	81,715.49	5,021.03	86,736.52
Indiana	54,183.63	1,227.25	94.38	51.10	286.88		479.36	4,699.65	1,783.47	94.72		62,900.44		62,900.44
Iowa	60,833.52	22.96	23.43	.40				3,000.71	973.62			64,854.64		64,854.64
Kansas	43,972.64	255.30	111.84			126.14	91.29	4,477.80	882.94	133.01		50,050.96		50,050.96
Kentucky	73,823.36	636.27	18.79			2,096.99	177.81	3,343.06	1,437.04			81,533.32		81,533.32
Louisiana	46,808.12	2,473.51	57.50	31.81		349.06	472.77	5,055.21	1,227.45	27.37		56,502.80		56,502.80
Maine	16,262.40	1,087.47	9.34	1.14	168.00	958.90	113.49	1,454.56	636.86			20,692.16		20,692.16
Maryland	22,113.13	405.52	46.76	93.92	412.37	50.80	80.99	3,983.79	2,935.06	137.38		30,259.72		30,259.72
Massachusetts	18,652.63								22.29			18,674.92		18,674.92
Michigan	63,004.91	724.46	47.73	1.20	150.56	1,054.42	241.18	5,227.25	3,114.89			73,566.60		73,566.60
Minnesota	44,188.46	2,179.33	265.39	25.45	49.62	85.00	580.79	7,432.39	1,861.26		601.35	57,269.04		57,269.04
Mississippi	55,130.08	1,099.56	636.45	405.82	1,753.57	1,749.07	1,367.80	8,250.28	1,854.30	404.47		72,651.40		72,651.40
Missouri	47,028.34	565.49	257.27	454.15	826.28	2,585.68	1,131.20	17,995.18	2,546.08	2,288.15	697.30	76,375.12	592.68	76,967.80
Montana	13,600.12	[illegible] 4.30	9.55		[illegible] 1,378.71		3.08	484.95	22.45			15,503.16		15,503.16
Nebraska	33,305.09	679.79	26.33	6.45	300.00	203.79	169.96	3,179.11	906.08			38,776.60		38,776.60
Nevada	2,248.67	51.30				197.15		44.27	193.25			2,734.64		2,734.64

New Hampshire	5,491.01	674.02	9.38	52.85	132.00	334.36	35.89	476.64	1,301.25			8,507.40		8,507.40
New Jersey	25,532.35	679.93	4.94	67.91	98.00	64.00	185.41	3,932.46	397.07	298.25		31,260.32		31,260.32
New Mexico	10,336.50		29.01	19.95	148.73	209.78	100.58	1,708.96	1,962.49			14,516.00		14,516.00
New York:														
Cornell	65,441.47	1,370.89	54.98	9.80	973.07	836.22	922.84	9,163.16	6,160.96			84,933.39	97.01	85,030.40
State	7,052.13	55.17		5.95		42.94		738.69	1,552.96			9,447.84		9,447.84
North Carolina	85,225.91	4,152.40	331.14	364.10	1,170.66	31.07	780.02	9,350.31	4,679.95			106,085.56		106,085.56
North Dakota	19,068.24	122.66	53.81	97.47	18.63	501.12	151.49	3,063.27	1,446.07	148.00		24,675.76		24,675.76
Ohio	71,914.84	1,012.91	81.44		992.00	65.52	68.93	6,176.08	3,811.97	7,500.00		91,623.69	2,093.95	93,717.64
Oklahoma	44,246.68	218.80	153.97	32.27	145.37	215.44	755.34	16,245.44	5,852.65	584.88		68,450.84		68,450.84
Oregon	17,992.22	622.78	100.40	78.82	21.91	247.15	242.11	1,498.19	1,822.78	163.96		22,790.32		22,790.32
Pennsylvania	111,486.07	2,628.23	113.97	51.20	6.60	604.69	218.65	10,719.88	7,725.73	1,767.62		135,322.64		135,322.64
Puerto Rico	35,302.76	54.55	44.16		525.83		13.04	7,378.24	7,458.15			50,776.73	2,436.51	53,213.24
Rhode Island	2,424.83							24.21				2,449.04		2,449.04
South Carolina	44,988.19	259.44	512.53	224.76	448.40	7.42	264.41	8,352.43	4,209.54		197.84	59,464.96		59,464.96
South Dakota	17,985.14	491.18	17.01	34.62		261.61	48.60	4,400.12	1,194.16			24,432.44		24,432.44
Tennessee	62,073.21	732.67	307.10	98.72	433.82	53.65	918.55	8,946.40	2,959.28	612.64		77,136.04		77,136.04
Texas	120,475.27	3,350.52	425.86	80.70	7.82		3,047.75	17,229.94	4,705.40	71.50		149,364.76		149,364.76
Utah	9,433.94	638.52			75.00		45.16	303.28	7.78			10,503.68		10,503.68
Vermont	8,831.75	24.51	2.31	2.89	25.52		111.64	209.70	173.02			9,381.34	1,090.26	10,471.60
Virginia	47,662.89	1,326.18	20.13	55.03	456.86	599.75	692.37	9,564.55	2,787.68	336.97	540.28	64,042.69	7,101.87	71,144.56
Washington	26,975.10	2,103.86	102.80	7.52	47.48		235.24	2,459.08	724.42	193.64	405.50	33,254.64		33,254.64
West Virginia	45,998.46	1,655.70	22.96	3.05	738.80	1,114.56	202.90	4,927.68	1,195.05			55,859.16		55,859.16
Wisconsin	56,684.16	174.80	216.86				56.08	3,092.88				60,224.88		60,224.88
Wyoming	5,298.43	509.54	5.71				91.89	159.51	694.44			6,759.52		6,759.52
Total	1,925,932.25	44,088.98	5,790.35	2,986.78	16,146.54	21,391.41	21,334.20	272,903.93	106,089.22	22,789.16	4,740.87	2,444,223.69	19,483.39	2,463,707.08

TABLE 7.—*Expenditures from non-Federal funds for the year ended June 30, 1943*

Station	Personal services	Travel	Transportation of things	Communication services	Rents and utility services	Printing and binding	Other contractural services	Supplies and materials	Equipment	Lands and structures (contractural)	Contributions to retirement	Total
Alabama	$130,371.66	$8,835.41	$2,021.26	$1,710.82	$4,689.03	$546.05	$7,461.28	$53,533.07	$11,457.91	$1,394.91		$222,021.40
Alaska	14,410.95	68.37	816.62	211.73	1,639.57	81.90	714.01	5,519.27	1,744.45	698.30		25,905.17
Arizona	87,846.72	8,621.33	428.53	965.53	2,658.77	2,784.89	4,869.18	13,593.16	3,141.49			124,909.60
Arkansas	100,002.71	10,824.38	192.83	2,294.97	7,334.87	442.74	2,485.96	27,912.26	10,554.57	4,096.68	$2,485.94	168,627.91
California	952,846.06	44,942.30	7,233.31	13,486.43	27,794.13	40,589.61	11,419.74	84,504.21	27,582.21			1,210,398.00
Colorado	81,153.84	4,525.63	766.49	1,612.20	9,476.89	3,148.03	6,537.99	29,192.10	13,093.96	5,069.98	654.55	155,231.66
Connecticut:												
State	127,879.92	1,482.08	89.73	1,354.00	3,537.81	104.95	1,119.04	12,990.40	3,907.16			152,465.09
Storrs	56,824.31	1,913.82	93.90	541.82	671.17	92.28	559.94	9,977.52	4,900.35			75,575.11
Delaware	33,190.73	895.12	721.85	1,005.99	4,180.55	250.00	945.13	30,489.41	3,209.89	3,537.13		78,425.80
Florida	393,787.23	13,920.94	3,045.78	4,309.89	12,011.29	7,357.02	11,909.93	101,058.99	23,601.54	23,771.77	2,716.21	597,490.59
Georgia	51,501.99	1,791.70	318.55	1,322.73	5,518.49	636.78	4,000.06	20,639.32	4,963.21	4,318.63		95,071.46
Hawaii	101,311.30	525.02	409.61	884.50	4,301.88	7,067.02	5,983.90	18,196.37	4,337.83			143,017.43
Idaho	40,846.83	3,000.00	1,400.00	900.00	2,500.00	2,200.00	3,500.00	27,000.00	3,500.00			84,846.83
Illinois	383,972.63	23,000.00		8,000.00		16,000.00		114,755.70	15,546.17			561,274.50
Indiana	351,413.81	10,552.44	3,613.46	5,728.92	12,721.18	7,972.13	14,116.58	197,125.44	33,697.01	6,095.03	3,100.00	646,136.00
Iowa	232,198.97	10,228.16	1,742.82	2,989.76	1,826.23	18,049.60	416.67	98,159.08	25,881.79	24,150.00		415,643.08
Kansas	139,120.97	4,245.69	1,090.68	2,153.68	6,640.45	2,309.19	7,186.79	40,023.34	15,059.97	6,096.73		223,927.49
Kentucky	197,354.77	4,694.10	1,227.44	3,115.02	14,579.94	2,194.70	13,976.37	36,640.64	12,997.64	22,269.52		309,050.14
Louisiana	155,279.90	12,595.15	956.53	2,228.03	4,680.36	3,354.41	6,704.05	34,754.86	17,117.34	2,439.59		240,110.22
Maine	66,853.86	3,814.55	2,206.92	714.33	7,849.94	2,145.09	2,544.22	13,569.43	2,925.71	276.33		102,900.38
Maryland	62,515.65	3,280.89	661.75	1,581.31	1,773.51	1,263.87	5,160.48	59,146.45	14,903.92	8,111.37	8,475.00	166,874.20
Massachusetts	120,857.87	2,333.58	259.91	1,365.44	589.79	3,127.28	1,585.27	12,304.99	3,947.33	534.35		146,905.81
Michigan	201,247.58	8,201.77	1,205.71	841.47	2,002.62	11,125.03	7,133.74	31,824.04	11,316.34	1,522.11		276,420.41
Minnesota	325,040.81	6,023.69	2,166.95	5,574.17	5,601.01	2,811.86	21,844.28	71,929.47	13,893.58	2,525.68		457,411.50
Mississippi	145,512.04	4,900.25	1,521.69	1,442.43	4,387.39	1,324.95	4,429.37	23,678.78	18,640.73	20,923.76		226,761.39
Missouri	85,152.84	5,100.65	874.94	1,497.85	4,441.86	10,170.81	6,182.02	44,878.11	15,392.75	2,609.68		176,301.51
Montana	96,861.13	2,679.48	821.56	1,491.86	6,663.45	1,984.04	5,949.17	32,911.28	13,585.93	5,192.56		168,143.46
Nebraska	86,417.02	4,637.41	1,452.63	1,925.07	6,883.58	3,032.16	2,350.77	68,472.90	50,109.74	4,117.74		229,404.02
Nevada	1,278.95	549.81	132.58	97.67	2,354.10	711.18	1,074.01	3,166.10	1,674.59	4,166.84		15,205.83

New Hampshire	8,252.64	77.10	10.36			444.23		502.81	648.95	1,174.86		11,110.95
New Jersey	390,243.37	6,671.43	369.87	9,164.96	19,159.06	11,823.00	13,895.68	73,198.49	4,842.25	199.00	438.58	530,005.69
New Mexico	26,705.58	702.00	188.96	730.85	1,144.50	570.24	2,143.70	7,366.39	840.29	5,464.43		45,856.94
New York:												
Cornell	613,043.16	17,971.98	1,603.98	6,161.81	43,407.14	8,988.10	13,422.71	87,309.04	31,130.79			823,038.71
State	310,458.68	6,328.90	559.12	3,509.14	8,694.53	7,692.02	7,654.12	36,428.98	7,144.27			388,469.76
North Carolina	113,782.33	9,460.71	640.47	2,112.43	2,689.07	1,534.54	3,395.97	30,626.01	20,562.48	1,042.53		185,846.54
North Dakota	45,667.54	1,616.02	357.18	689.78	20,765.12	2,373.20	2,967.31	17,783.59	7,827.86	1,774.17		101,821.77
Ohio	433,311.70	8,444.83	2,350.51	3,246.72	12,562.40	26,967.85	14,331.29	109,859.22	30,530.84	11,752.15		653,357.51
Oklahoma	186,434.22	4,693.14	558.32	1,071.21	4,167.40	1,644.67	1,232.64	93,249.35	14,169.53	3,272.19		310,492.67
Oregon	259,438.93	8,422.92	1,582.44	3,276.68	9,171.07	4,254.79	12,247.88	51,868.97	27,108.28	4,658.48		382,030.44
Pennsylvania	153,064.27	8,303.53	3.56	901.08	2,138.17	2,532.17	4,288.28	51,621.03	14,036.36	1,500.00		238,388.45
Puerto Rico	155,418.34	2,619.25	330.28	1,218.77	6,699.78	4,021.02	1,231.23	25,634.93	5,563.25	765.85		203,502.70
Rhode Island	5,611.05	351.85	42.63	157.98	561.47	573.35	387.21	1,676.43	937.91	31.05		10,330.93
South Carolina	116,129.30	2,254.66	4,695.15	1,651.16	5,272.26	782.24	15,828.52	107,141.47	18,713.36	3,363.09	868.51	276,699.72
South Dakota	32,348.43	1,598.93	227.51	202.81	449.64	1,456.91	793.21	20,698.75	8,547.73	146.62		66,470.54
Tennessee	66,843.71	1,025.35	955.23	762.12	1,363.91	919.70	4,453.35	5,673.42	40,907.43	3,449.65		126,353.87
Texas	402,262.94	5,940.53	1,345.79	3,291.87	14,056.20	3,790.82	51,559.85	102,173.40	67,701.53	24,119.79	18,932.80	695,175.52
Utah	31,957.50	1,359.80	202.16	912.23	4,671.43	3,364.80	1,252.21	9,411.19	3,468.78	18,637.10	1,821.00	77,058.20
Vermont	8,875.35	18.55	16.78	4.00	27.17	11.94	761.41	433.87	37.00			10,186.07
Virginia	94,517.04	5,549.19	767.86	1,749.93	4,964.24	3,561.73	5,340.18	12,734.96	7,627.92	3,659.23	265.24	140,737.52
Washington	187,504.28	7,658.95	1,503.38	2,183.15	5,912.11	3,690.32	9,039.59	53,429.31	16,303.71	3,381.09	1,816.08	292,421.97
West Virginia	66,827.02	2,768.69	234.58	1,167.23	4,755.19	1,153.31	1,456.84	34,784.76	11,367.32	15,491.20		140,006.14
Wisconsin	481,846.00	14,714.00	852.00	1,427.00	6,275.00	4,268.00	9,487.00	121,910.00	26,661.00			667,440.00
Wyoming	38,034.75	975.91	354.76	449.75	1,191.76	69.54		35,976.40	3,278.22			80,331.09
Total	9,051,631.18	327,711.94	57,226.91	117,390.28	349,416.48	249,366.06	339,330.13	2,409,499.46	752,642.17	257,801.17	41,573.91	13,953,589.69

TABLE 8.—*Disbursements from the U. S. Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the Hatch Act (Mar. 2, 1887), Adams Act (Mar. 16, 1906), Purnell Act (Feb. 24, 1925), Bankhead-Jones Act (June 29, 1935), and supplementary acts*

State or Territory	Hatch Act 1888–1943	Adams Act 1906–43	Purnell Act 1926–43	Bankhead-Jones Act 1936–43
Alabama	$839,199.34	$536,619.89	$980,000.00	$527,181.39
Alaska	180,000.00	45,000.00	10,000.00	14,136.62
Arizona	804,467.73	539,995.61	979,986.80	80,919.02
Arkansas	838,127.12	539,900.00	980,000.00	407,892.90
California	840,000.00	539,926.84	980,000.00	452,283.35
Colorado	839,718.82	538,638.93	980,000.00	142,997.37
Connecticut	839,957.38	540,000.00	979,648.85	135,345.83
Dakota Territory	56,250.00			
Delaware	838,382.87	535,982.26	976,099.27	32,299.55
Florida	839,966.06	539,996.06	976,523.74	204,321.49
Georgia	835,593.43	527,092.87	980,000.00	557,958.62
Hawaii	209,919.17	164,531.58	207,500.00	58,563.30
Idaho	764,824.13	535,842.22	980,000.00	88,458.38
Illinois	838,114.11	539,718.69	977,264.29	552,552.53
Indiana	839,901.19	535,000.00	980,000.00	397,974.79
Iowa	840,000.00	540,000.00	977,965.17	413,448.33
Kansas	839,995.00	540,000.00	980,000.00	319,074.87
Kentucky	839,996.57	540,000.00	980,000.00	508,420.56
Louisiana	840,000.00	540,000.00	980,000.00	354,214.40
Maine	839,999.62	540,000.00	980,000.00	131,912.52
Maryland	839,967.40	539,236.48	980,000.00	185,427.79
Massachusetts	839,617.70	540,000.00	979,997.65	116,896.97
Michigan	839,676.10	536,341.60	980,000.00	440,117.50
Minnesota	839,917.78	539,345.74	980,000.00	363,027.75
Mississippi	840,000.00	540,000.00	980,000.00	463,152.68
Missouri	835,097.24	539,999.90	980,000.00	490,669.72
Montana	750,000.00	537,417.04	980,000.00	98,832.65
Nebraska	839,932.16	540,000.00	979,995.00	247,260.82
Nevada	838,331.08	536,145.10	980,000.00	16,234.58
New Hampshire	839,250.00	540,000.00	980,000.00	53,577.55
New Jersey	839,959.97	539,392.06	980,000.00	196,071.19
New Mexico	804,509.05	540,000.00	980,000.00	89,236.38
New York	839,757.54	539,189.22	979,831.15	581,921.89
North Carolina	840,000.00	540,000.00	980,000.00	661,168.62
North Dakota	796,491.45	539,605.60	979,737.21	157,217.37
Ohio	840,000.00	538,514.02	980,000.00	594,374.86
Oklahoma	771,919.88	527,842.65	979,907.72	435,865.72
Oregon	825,156.64	535,000.00	980,000.00	133,849.77
Pennsylvania	839,967.43	539,995.41	980,000.00	859,911.93
Puerto Rico	134,762.63	123,724.28	99,348.60	311,536.11
Rhode Island	839,936.24	534,423.07	979,670.62	14,629.89
South Carolina	839,541.37	538,360.12	980,000.00	379,039.12
South Dakota	783,250.00	535,000.00	980,000.00	155,756.80
Tennessee	840,000.00	540,000.00	980,000.00	481,451.56
Texas	840,000.00	537,592.26	980,000.00	952,200.34
Utah	805,000.00	539,821.94	980,000.00	66,960.96
Vermont	840,000.00	539,498.36	980,000.00	66,756.45
Virginia	838,766.58	538,544.94	979,994.27	453,546.57
Washington	778,414.70	536,080.11	980,000.00	195,640.56
West Virginia	839,804.16	536,263.82	979,942.89	347,152.12
Wisconsin	840,000.00	540,000.00	980,000.00	383,932.93
Wyoming	795,000.00	538,850.59	980,000.00	43,091.94
Total	40,318,439.64	26,164,429.26	47,343,413.23	15,416,456.91

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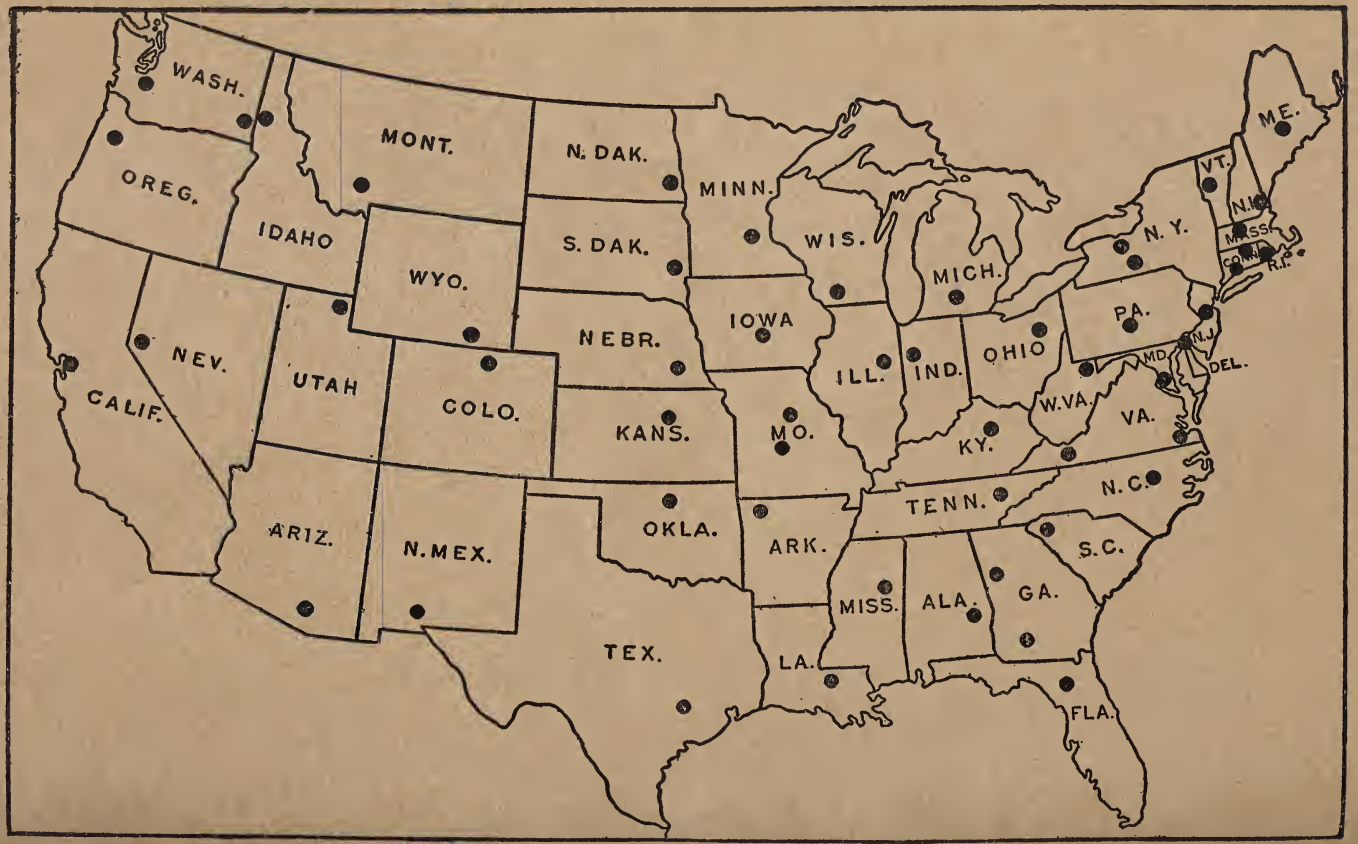
NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.



HEADQUARTERS OF STATE AGRICULTURAL EXPERIMENT STATIONS